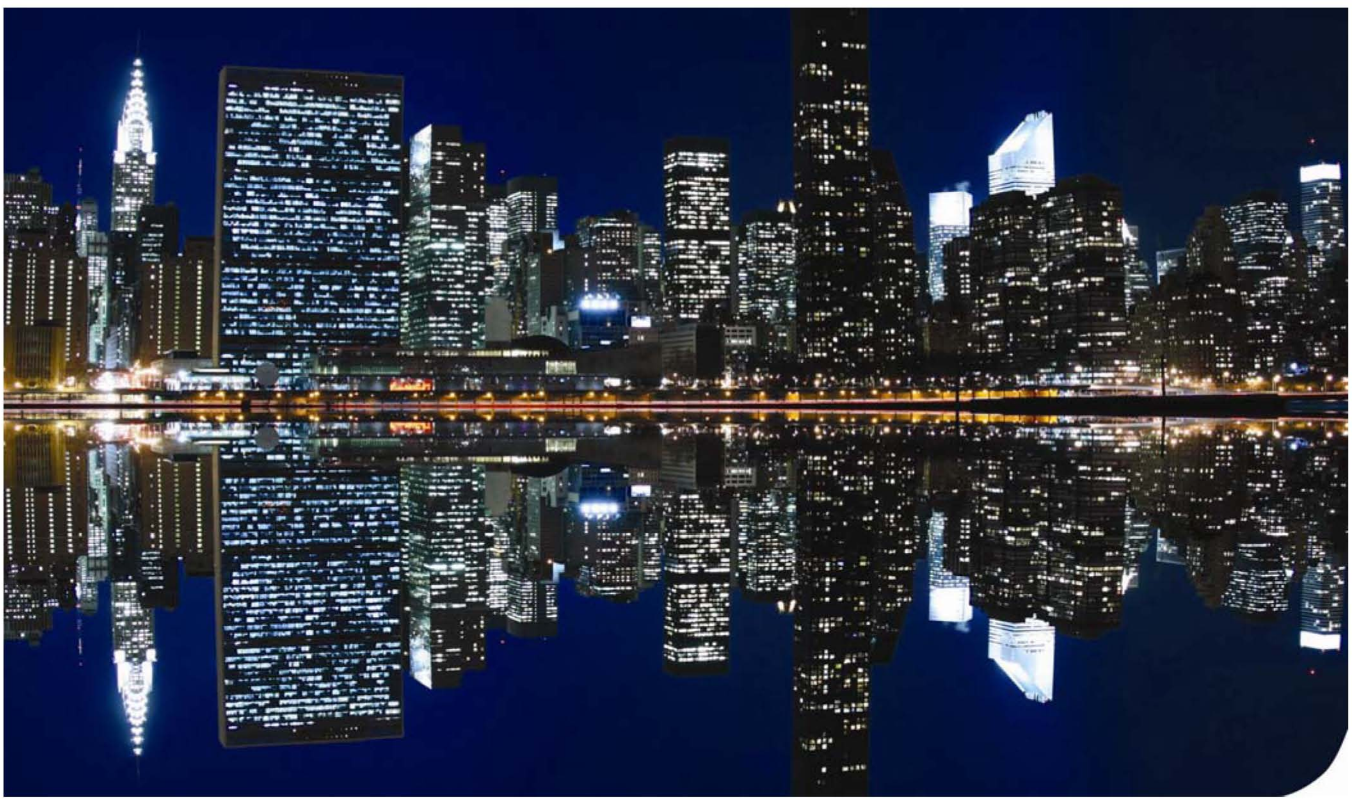
EnergyWise^{SM} Initial
2009 Summer Load Impact Report

Progress Energy Carolinas



Raleigh, North Carolina, December 28, 2010

Experience you can trust.

Table of Contents

Table of Contents

List of Exhibits:

Table of Contents

Table of Contents

Table of Contents

1. Executive Summary

This report presents the initial load impact estimates for the 2009 EnergyWise summer season based on the first of two planned M&V efforts. At the time of this initial M&V effort, the EnergyWise program was in its infancy and the number of participants enrolled in the program was low. Additional M&V effort is warranted to confirm the results of this initial effort.

This section provides a brief summary of the findings described in this report.

The central objective of this document is to describe the 2009 performance and expected future performance of Progress Energy Carolina's summer EnergyWise program.

EnergyWise is a direct load control program that has the capability to reduce load at times of peak electricity demand and thereby defer the need for additional peaking capacity resources. The North Carolina Utilities Commission approved the program on October 14, 2008.

The summer program is offered in most of PEC's service territory, and it consists of direct load control of air conditioners.

The methodology employed in the load impacts measurement and verification (M&V) of the EnergyWise summer 2009 season included the following elements:

- Load Data Collection
- System Load and Temperature Data Analysis for M&V Event Plan
- Load Data Preparation
- Load Data Modeling for 2009 estimates: kW and kWh savings and snapback by hour for each M&V event conducted, at the participant level
- Weather Data Analysis for load impact projections
- Load Impact Projections for different temperature conditions and control strategies

Prior to this study, the program's expectation was that air conditioner load would be higher than what is reflected in this study. In order to verify the quality of the air conditioner data utilized in the summer analysis, KEMA tested all of the loggers that were utilized in this study.

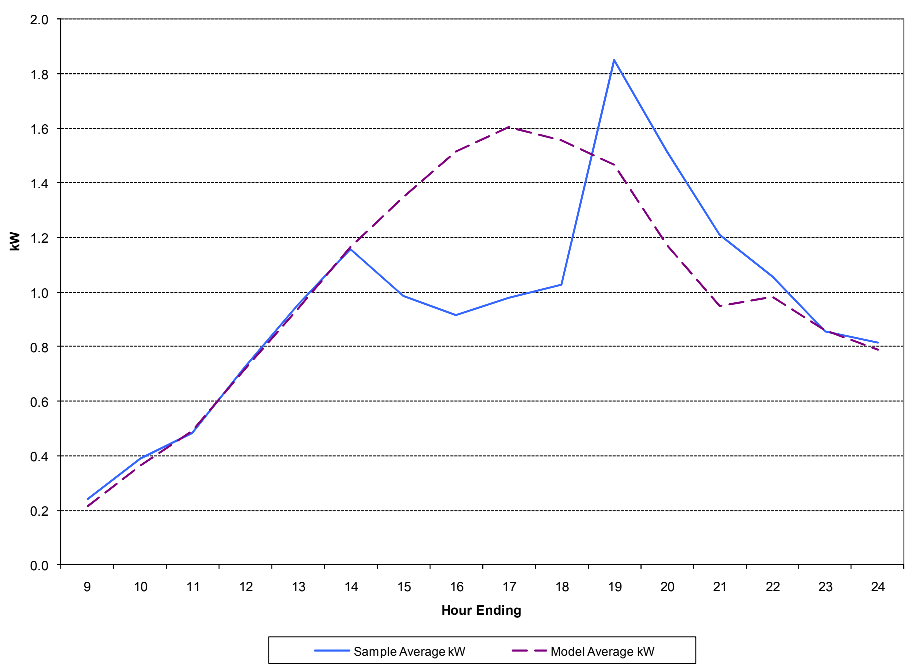
1.1 Summer 2009 Load Impact Estimates

At the beginning of the 2009 summer season there were 1,803 air conditioning units participating in the EnergyWise program. The sample size utilized in the summer M&V effort was approximately 6 percent of these units.

There were ten direct load control events included in the 2009 summer M&V effort. The direct load control of air conditioners consisted of 50 or 75 percent adaptive cycling – air conditioners were allowed to run at half to 25 percent of the expected duty cycle. The expected duty cycle is calculated by the DLC device based on proprietary algorithms developed by the device manufacturer and information recorded by the device on prior days with no event selected by the program administrator ("ideal control days"), or on the hour prior to the start of the event ("prior hour").

Figure 1-1 presents the average baseline and load on the day of event estimates for the ten EnergyWise events conducted in the summer of 2009. The average load reduction during event hours was 0.5 kW.

Figure 1-1
Air Conditioning Baseline Average (from Model)
Vs Event Day Average (from M&V Sample)



1.2 Load Impact Projections

Load impact projections were developed for a number of scenarios, defined by the following parameters:

- **Weather Year** – typical or extreme
- **Region** - the three geographical areas in which the EnergyWise Program operates in North Carolina
- **Number of Air Conditioners at the Premise** - Single (one AC) and Multiple (two or more ACs)
- **Percent Cycling** - percent of the AC's duty cycle that is interrupted using an adaptive algorithm
- **Adaptive Cycling Algorithm** - the type of adaptive algorithm used in the event: *Ideal Control Day* (ICD) or *Prior Hour*
- **Load Impact Adjustment** - a factor applied to the load impact projections to account for rate of non-response and other deviations from "perfect" DLC device performance[1].

Table 1-1 and Table 1-2 include the program design assumptions ("PEC Deemed Savings") regarding central air conditioner impacts, and the estimated projections at 50 percent cycling between 2 and 6 PM, for program participants with one AC unit and with multiple AC units, respectively. Table 1-2 shows that on days with extreme temperatures, participants in Raleigh and Wilmington with multiple units would meet deemed savings at a 50 percent level of cycling.

Table 1-3 through Table 1-6 present the same comparisons, at 75 and 100 percent cycling, respectively. At 75 percent cycling, the program meets deemed savings with single-unit households in Raleigh and Wilmington in extreme hot years. At 100 percent cycling, all combinations of region, weather type and number of units meet or exceed deemed savings (except for single-unit participants in Asheville in a typical year).

[1] There are a number of valid reasons why DLC device performance is, on average, not "perfect". These are discussed in Section 3.2.6 Load Impact Adjustment Effect.

The estimated load impacts in these tables correspond to the following scenario:

1. The load impact projections selected are for days with the maximum load impact in the Raleigh region.

2. Event is from 2 to 6 PM

3. Rate of non-response is about 0.5 percent

4. The “Extreme” weather year is the hottest of ten years. The “Typical” weather year is defined as the median year based on the temperatures of the three hottest days of each of the ten years. Half of the years are colder than “typical”, and the other half are hotter.

Table 1-1
Deemed Savings Vs Central Air Conditioning Regional Load Impact Projections
Participants with Single AC Units – 50 Percent Cycling

Weather Type	Maximum Daily Temperature (°F)	Average Load Impact (kW)	Total Load Impact (kWh)	Average Snapback (kW)	Total Snapback (kWh)	Total Savings (kWh)
Deemed Savings						
		1.21				0.90
Asheville						
Extreme	92	0.55	2.22	0.18	1.10	1.12
Typical	89	0.45	1.81	0.15	0.90	0.91
Raleigh						
Extreme	104	0.86	3.43	0.27	1.61	1.82
Typical	96	0.67	2.69	0.22	1.30	1.38
Wilmington						
Extreme	96	0.74	2.96	0.24	1.44	1.53
Typical	91	0.60	2.38	0.20	1.19	1.19

Table 1-2
Deemed Savings Vs Central Air Conditioning Regional Load Impact Projections
Participants with Multiple AC Units – 50 Percent Cycling

Weather Type	Maximum Daily Temperature (°F)	Average Load Impact (kW)	Total Load Impact (kWh)	Average Snapback (kW)	Total Snapback (kWh)	Total Savings (kWh)
Deemed Savings						
		1.21				0.90
Asheville						
Extreme	92	0.80	3.20	0.27	1.60	1.60
Typical	89	0.64	2.54	0.21	1.28	1.26
Raleigh						
Extreme	104	1.41	5.64	0.43	2.58	3.06
Typical	96	1.03	4.10	0.33	1.97	2.13
Wilmington						
Extreme	96	1.10	4.41	0.35	2.12	2.29
Typical	91	0.77	3.09	0.26	1.57	1.53

Table 1-3
Deemed Savings Vs Central Air Conditioning Regional Load Impact Projections
Participants with Single AC Units – 75 Percent Cycling

Weather Type	Maximum Daily Temperature °F	Average Load Impact (kW)	Total Load Impact (kWh)	Average Snapback (kW)	Total Snapback (kWh)	Total Savings (kWh)
Deemed Savings						
		1.21				0.90
Asheville						
Extreme	92	0.79	3.16	0.25	1.53	1.64
Typical	89	0.64	2.55	0.20	1.23	1.32
Raleigh						
Extreme	104	1.3	5.21	0.40	2.39	2.82
Typical	96	1.00	3.98	0.31	1.88	2.10
Wilmington						
Extreme	96	1.14	4.56	0.36	2.17	2.40
Typical	91	0.93	3.70	0.30	1.80	1.90

Table 1-4
Deemed Savings Vs Central Air Conditioning Regional Load Impact Projections
Participants with Multiple AC Units – 75 Percent Cycling

Weather Type	Maximum Daily Temperature °F	Average Load Impact (kW)	Total Load Impact (kWh)	Average Snapback (kW)	Total Snapback (kWh)	Total Savings (kWh)
Deemed Savings						
		1.21				0.90
Asheville						
Extreme	92	1.13	4.51	0.36	2.18	2.33
Typical	89	0.90	3.59	0.29	1.73	1.85
Raleigh						
Extreme	104	2.14	8.56	0.64	3.83	4.73
Typical	96	1.53	6.11	0.48	2.86	3.26
Wilmington						
Extreme	96	1.70	6.79	0.53	3.20	3.59
Typical	91	1.23	4.92	0.40	2.40	2.53

Table 1-5
Deemed Savings Vs Central Air Conditioning Regional Load Impact Projections
Participants with Single AC Units – 100 Percent Cycling

Weather Type	Maximum Daily Temperature °F	Average Load Impact (kW)	Total Load Impact (kWh)	Average Snapback (kW)	Total Snapback (kWh)	Total Savings (kWh)
Deemed Savings						
		1.21				0.90
Asheville						
Extreme	92	1.30	5.2	0.41	2.45	2.76
Typical	89	1.05	4.18	0.32	1.95	2.23
Raleigh						
Extreme	104	2.22	8.89	0.67	4.01	4.88
Typical	96	1.67	6.70	0.52	3.09	3.61
Wilmington						
Extreme	96	1.96	7.85	0.61	3.67	4.18
Typical	91	1.60	6.38	0.51	3.04	3.34

Table 1-6
Deemed Savings Vs Central Air Conditioning Regional Load Impact Projections
Participants with Multiple AC Units – 100 Percent Cycling

Weather Type	Maximum Daily Temperature °F	Average Load Impact (kW)	Total Load Impact (kWh)	Average Snapback (kW)	Total Snapback (kWh)	Total Savings (kWh)
Deemed Savings						
		1.21				0.90
Asheville						
Extreme	92	1.84	7.37	0.57	3.44	3.93
Typical	89	1.46	5.84	0.45	2.71	3.13
Raleigh						
Extreme	104	3.65	14.6	1.07	6.41	8.19
Typical	96	2.58	10.31	0.78	4.7	5.61
Wilmington						
Extreme	96	2.92	11.68	0.9	5.41	6.27
Typical	91	2.15	8.59	0.68	4.06	4.53

1.3 Non-Response Rates

A non-responsive unit is defined as a participating appliance that was operating at the time of the event, that did not reduce its load as a result of the event, and that does not have a record of an event opt-out. The two most common reasons for non-responsive units are signal problems (permanent or temporary) and DLC device malfunction.

The average non-response rate for air conditioners is estimated to be about 0.5 percent.

1.4 Recommendations

The measurement and verification study conducted in the summer of 2009 was the first of two M&V efforts planned by PEC and provides valuable information that can be used to potentially improve the future load impacts of PEC's EnergyWise program. Because this M&V study was conducted when the program had just kicked-off and had a low number of enrolled participants, the follow-up M&V that is planned for summer of 2011 is warranted and should provide additional data needed to make a comprehensive assessment of future load impacts.

1. **Investigate options to reduce the level of snapback**. While snapback is at levels that are common for this type of program, an early event could push snapback into a time of day when the system is still facing high demands from customers. These may include a staggered release from direct load control, which would cause snapback to spread over several hours. However, it would also cause some program participants to be in control mode longer than others. The consequences of such release have to be explored carefully, and possibly paired with customer research.

2. **Maintain non-response rates observed in the first stages of the program**. The summer program experienced very low rates of non-response in the summer of 2009. The same protocols that generated these results can continue to be observed to maintain this high level of performance. It is not uncommon to have some of these processes become laxer or more difficult to enforce as the program grows.

3. **Conduct further M&V activities with the following purposes:**

    a. **Understanding the load patterns and potential load impacts of program participants that are not first adopters**. There is substantial market research in the energy industry that proves that first adopters of a program such as EnergyWise tend to be different than those that join as the program matures. First adopters tend to be more focused on the environmental message of a program like this, and potentially more likely to tolerate discomfort.

    b. **Better understand the differences between the major regions in the PEC service territory**. This was not possible at the time of the first M&V study because the program was recruiting and installing mostly in the Raleigh area.

2. Summer 2009 EnergyWise Load Impacts

At the beginning of the 2009 summer season there were 1,803 air conditioning units subject to being controlled under the EnergyWise program, the vast majority of them located in the Raleigh region. The sample size utilized in the summer M&V effort was approximately 6 percent of all program participants.

There were ten summer M&V events conducted in the 2009 season. This section summarizes the load impact estimated for each these events. The direct load control of air conditioners consisted of 50 or 75 percent adaptive cycling – air conditioners were allowed to run at half to 25 percent of the expected duty cycle. The expected duty cycle is calculated by the DLC device based on proprietary algorithms developed by the device manufacturer and information recorded by the device on prior days with no event selected by the program administrator ("ideal control days"), or on the hour prior to the start of the event ("prior hour").

Prior to this study, the program's expectation was that air conditioner load would be higher than what is reflected in this study. In order to verify the quality of the air conditioner data utilized in the summer analysis, KEMA tested all of the loggers that were utilized in this study.

Figure 2-1 and Figure 2-2 illustrate the comparison between the load model estimates developed for this end-use, and the average load of the logged appliances.

The first figure is for weekdays with no events. It is clear that the model provides a good representation of the load. This is important because the model constitutes the basis to estimate the program's load impacts – it is used to estimate the baseline: what air conditioning use would have been if there had been no event.

Figure 2-1
Air Conditioning Average (from Model) vs Non-Event Day Average (from M&V Sample)

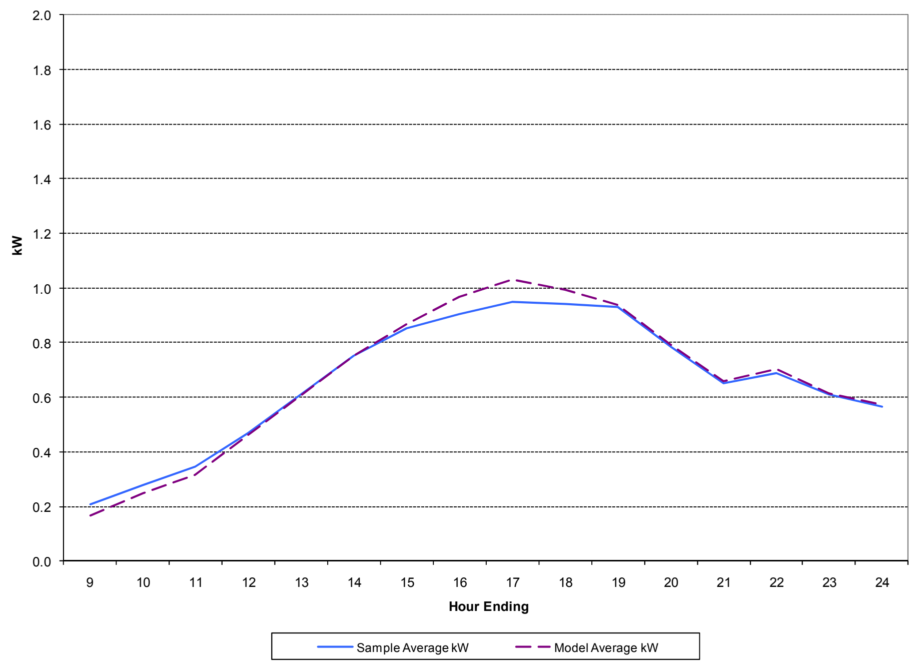
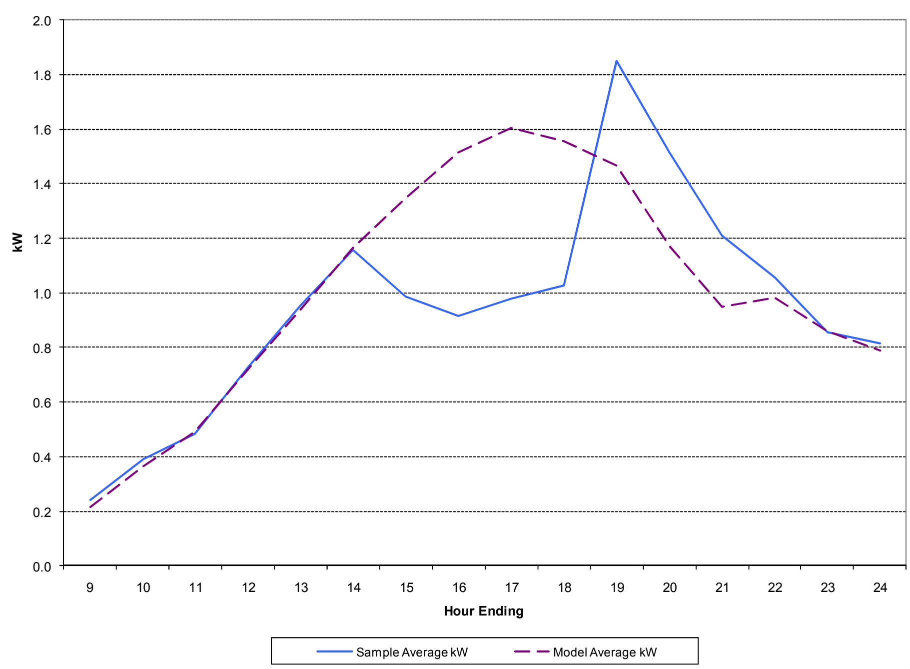


Figure 2-2
Air Conditioning Average (from Model) vs Event Day Average (from M&V Sample)



2.1 Event Day Air Conditioning Load Impacts

This section presents the estimated load impacts for central air conditioning during each of the M&V events conducted in the 2009 summer season.

Table 2-1 lists the ten M&V events that were conducted in 2009. The first two of these events affected all program participants and not just the M&V sample. However, since they were conducted for M&V purposes, they are considered M&V events.

The variables in this table include the date of each event, the time of day, the cycling strategy, the regions affected, the maximum daily temperature, the maximum temperatures observed that day, the estimated kW and kWh from the events' load reduction, and the corresponding snapback.

Table 2-1
EnergyWise Central Air Conditioning 2009 Load Impact Estimates

Date	Event Hours	Cycling	Region	Max Daily Temp*	Average Load Impact (kW)	Max Load Impact (kW)	First Hour Snapback (kW)	Event Energy Savings (kWh)	Total Snapback (kWh)	Total Energy Savings (kWh)
8/5/2009	2 to 6 PM	50%	All	94	0.78	0.90	-0.43	3.12	-1.60	1.51
8/10/2009	3 to 6 PM	50%	All	97	0.88	0.93	-0.31	2.63	-1.71	0.92
8/19/2009	2 to 6 PM	50%	All	94	0.59	0.61	-0.54	2.35	-1.97	0.38
8/20/2009	2 to 6 PM	50% in hour 1 and 4, 75% in hours 2 and 3	Raleigh and Wilmington	89	0.59	0.86	-0.49	2.37	-1.02	1.35
8/27/2009	2 to 6 PM	50%	All	92	0.72	0.73	-0.53	2.86	-0.87	2.00
8/28/2009	3 to 6 PM	75%	Raleigh	86	0.56	0.66	-0.55	1.67	-1.34	0.33
9/14/2009	3 to 6 PM	50%	All	85	0.39	0.42	-0.22	1.18	-0.34	0.83
9/24/2009	2 to 6 PM	50%	All	87	0.56	0.66	-0.40	2.23	-0.61	1.62
9/25/2009	3 to 6 PM	75%	Wilmington	79	0.17	0.21	-0.23	0.51	-0.59	-0.08
9/28/2009	3 to 6 PM	50%	All	84	0.14	0.17	-0.25	0.42	-0.49	-0.07

* Source: National Oceanic and Atmospheric Administration (NOAA).

Figure 2-3 illustrates the first event day of the summer for the average program participant. The model estimates a maximum load impact of 0.9 kW (with a 90% confidence interval of +/- 0.1) kW at hour ending 5 PM.

Figure 2-4 illustrates the same comparison, but for the subset of participants that have one air conditioner only. On this day, these participants are estimated to have a maximum load impact of about 0.8 kW (+/- 0.2 kW) at hour ending (HE) 5 PM. The load impacts for participants with multiple air conditioners are shown in Figure 2-5. These participants show a maximum impact of 1.1 kW (+/- 0.2 kW) at HE 5 PM.

Figure 2-3
Average Program Participant
August 5, 2009 – Cycling at 50% from 2 to 6 PM
(Raleigh 96°F, Asheville 84°F, Wilmington 91°F)

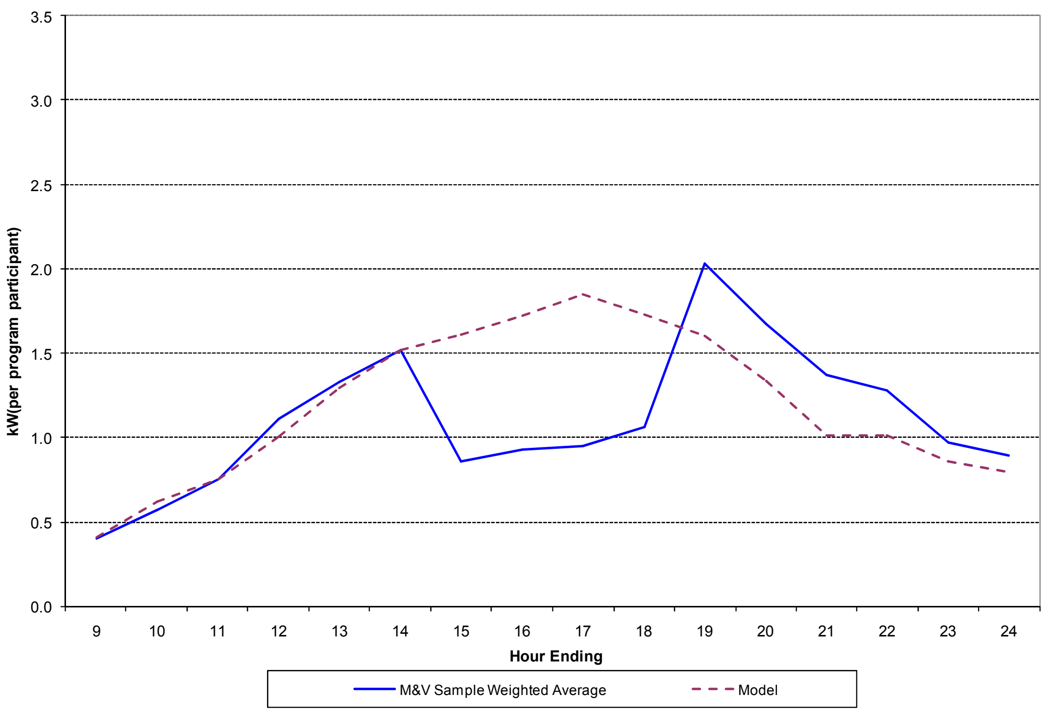


Figure 2-4
Average Program Participant with One Air Conditioner
August 5, 2009 – Cycling at 50% from 2 to 6 PM
(Raleigh 96°F, Asheville 84°F, Wilmington 91°F)

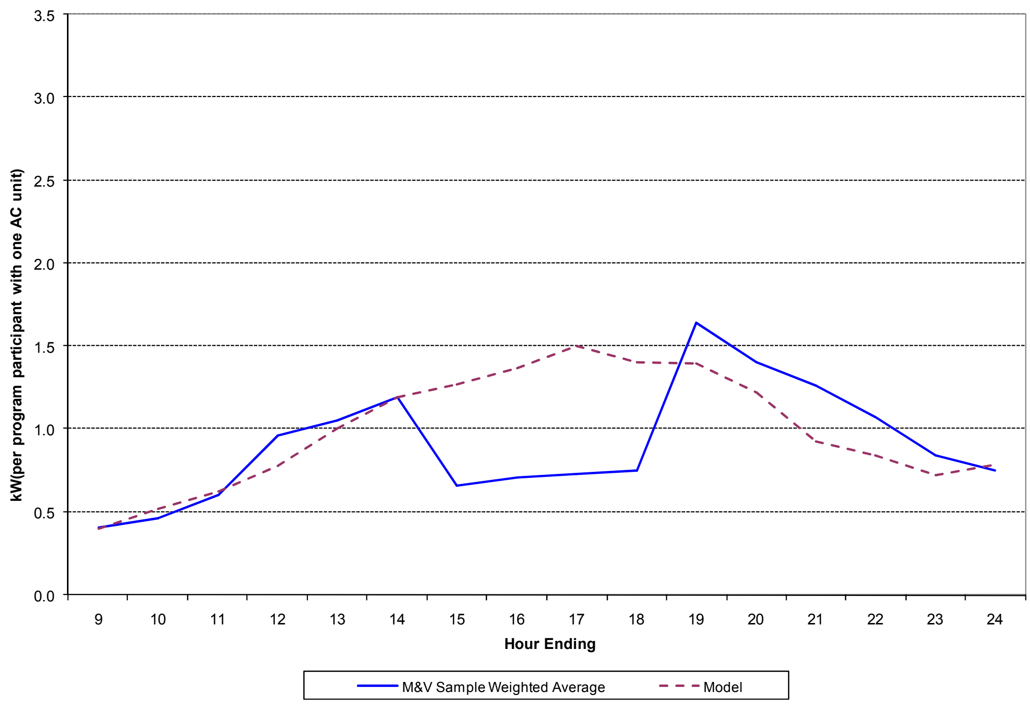


Figure 2-5
Average Program Participant with Multiple Air Conditioners
August 5, 2009 – Cycling at 50% from 2 to 6 PM
(Raleigh 96°F, Asheville 84°F, Wilmington 91°F)

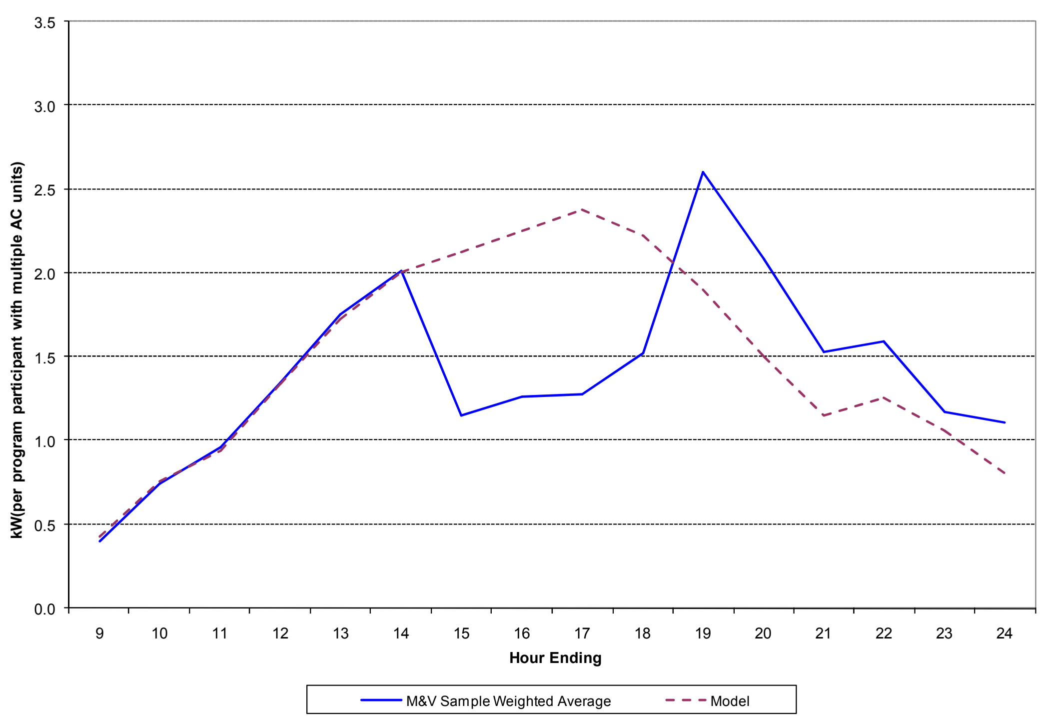


Figure 2-6 illustrates the event of August 10, one of the hottest days in the 2009 summer season. For the three event hours, the model estimates a maximum load impact for the average program participant of 0.9, 0.9, and 0.8 (+/- 0.2) kW, respectively.

Figure 2-7 presents the results for participants with one AC. The model estimates impacts of 0.7 (+/- 0.2), 0.7 (+/- 0.1), and 0.6 (+/- 0.2) kW.

Participants with multiple ACs are presented in Figure 2-8. The model estimates impacts of 1.3, 1.2, and 1.1 kW (+/- 0.3) for each of these three hours.

It is estimated that 10 percent of the AC units enrolled in EnergyWise were not operating at the time of the event. This is illustrated in Table 2-2. Since these impact estimates are an average per unit, all participating units are taken into account, whether they operate at the time of the event or not.

Figure 2-6 Average Program Participant
August 10, 2009 – Cycling at 50% from 3 to 6 PM
(Raleigh 99°F, Asheville 86°F, Wilmington 96°F)

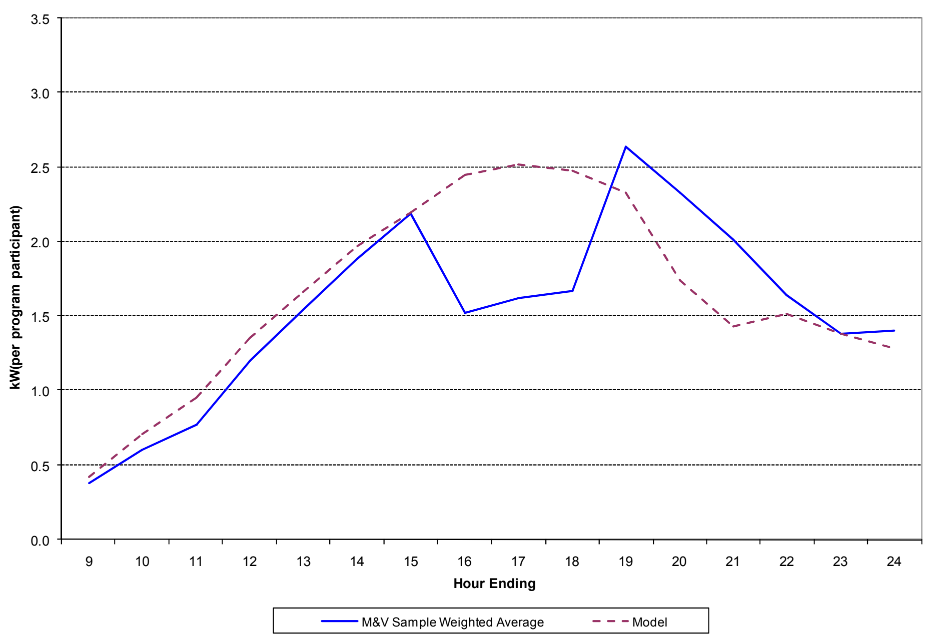


Figure 2-7 Average Program Participant with One Air Conditioner Unit August 10, 2009 – Cycling at 50% from 3 to 6 PM (Raleigh 99°F, Asheville 86°F, Wilmington 96°F)

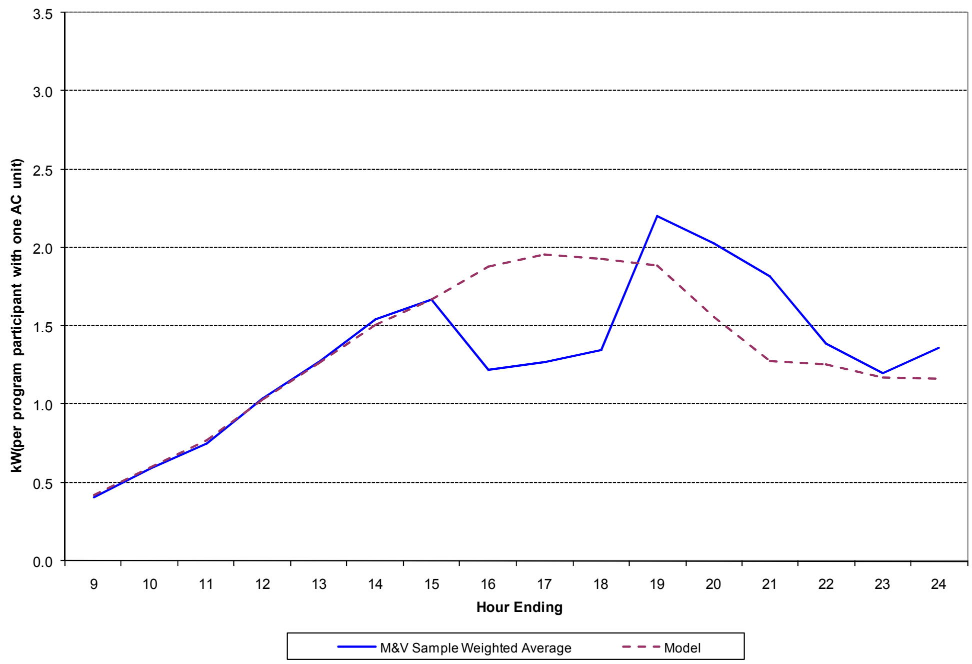


Figure 2-8 Average Program Participant with Multiple AC Units August 10, 2009 – Cycling at 50% from 3 to 6 PM (Raleigh 99°F, Asheville 86°F, Wilmington 96°F)

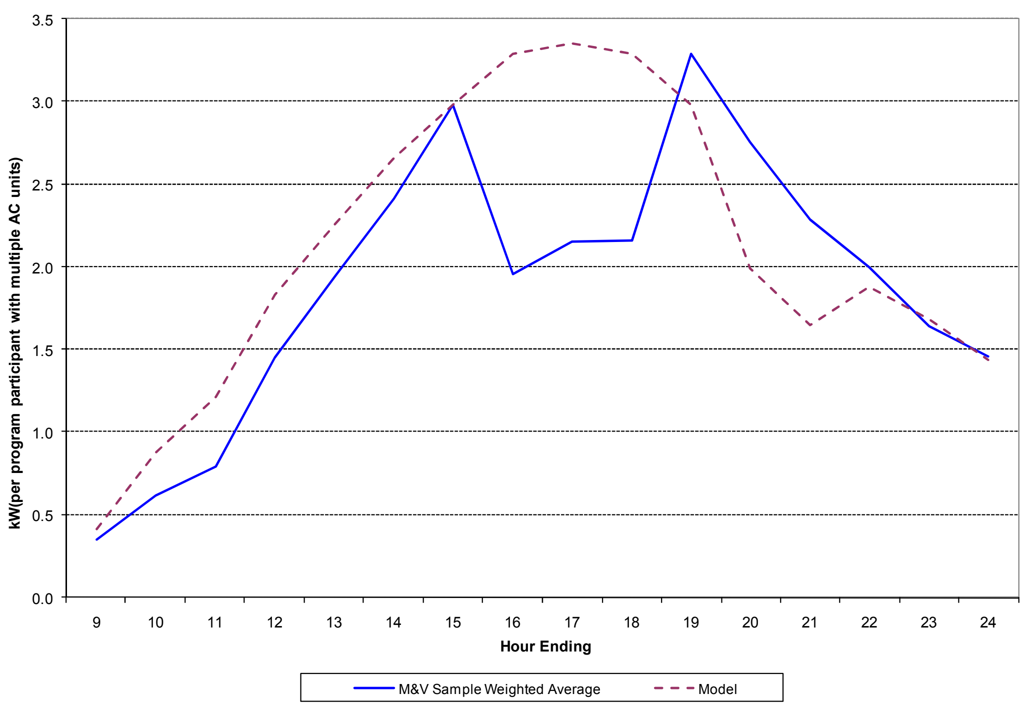


Figure 2-9 illustrates estimates of air conditioner use on August 11, a non-event day. The average program participant AC use is estimated to range between 1.9 and 2.4 kW between HE 2 PM and HE 7 PM – the window in which the need for system relief is more likely. During this time, the AC load for program participants with one AC is between 1.6 and 2.0 kW (Figure 2-10), and program participants with multiple units ranged between 2.2 and 3.1 kW (Figure 2-11).

Figure 2-9
Average Program Participant
August 11, 2009 – No Event
(Raleigh 99°F, Asheville 86°F, Wilmington 97°F)

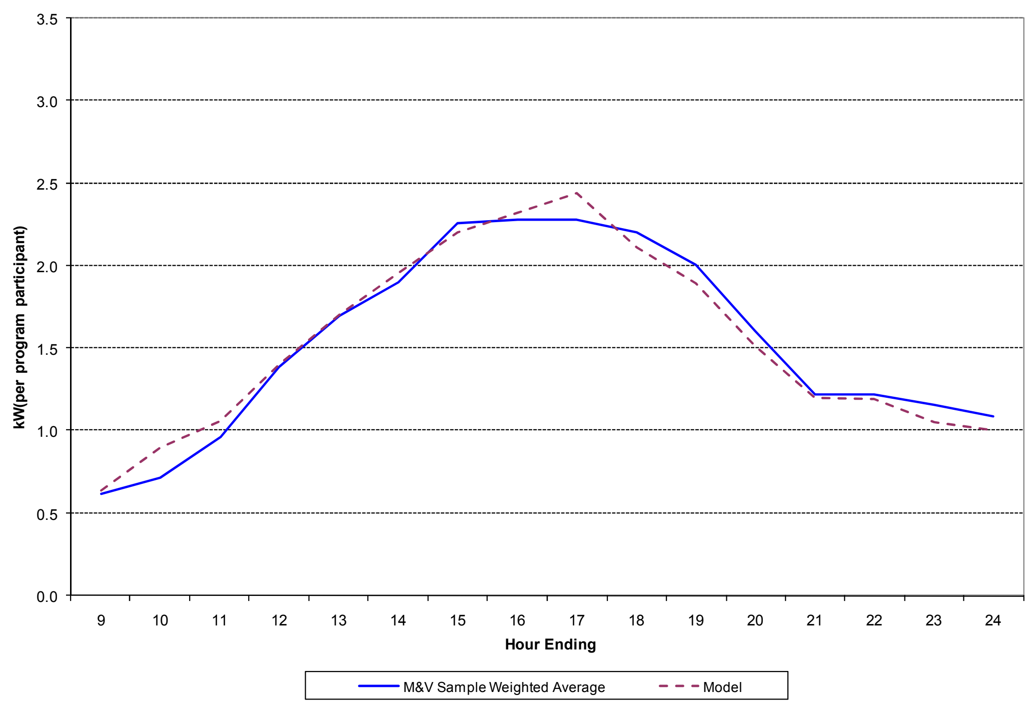


Figure 2-10
Average Program Participant with One AC Unit
August 11, 2009 – No Event
(Raleigh 99°F, Asheville 86°F, Wilmington 97°F)

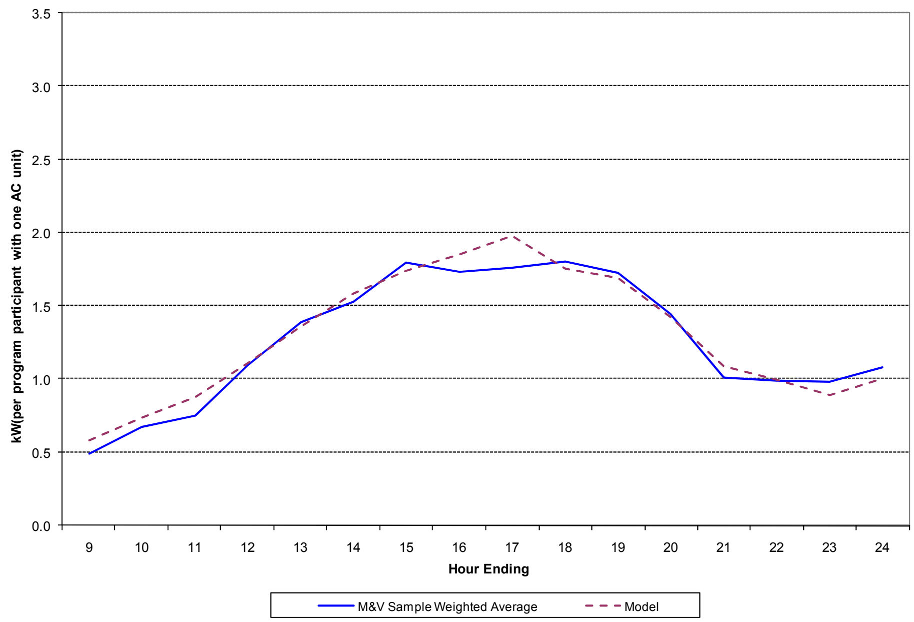


Figure 2-11
Average Program Participant with Multiple AC Units
August 11, 2009 – No Event
(Raleigh 99°F, Asheville 86°F, Wilmington 97°F)

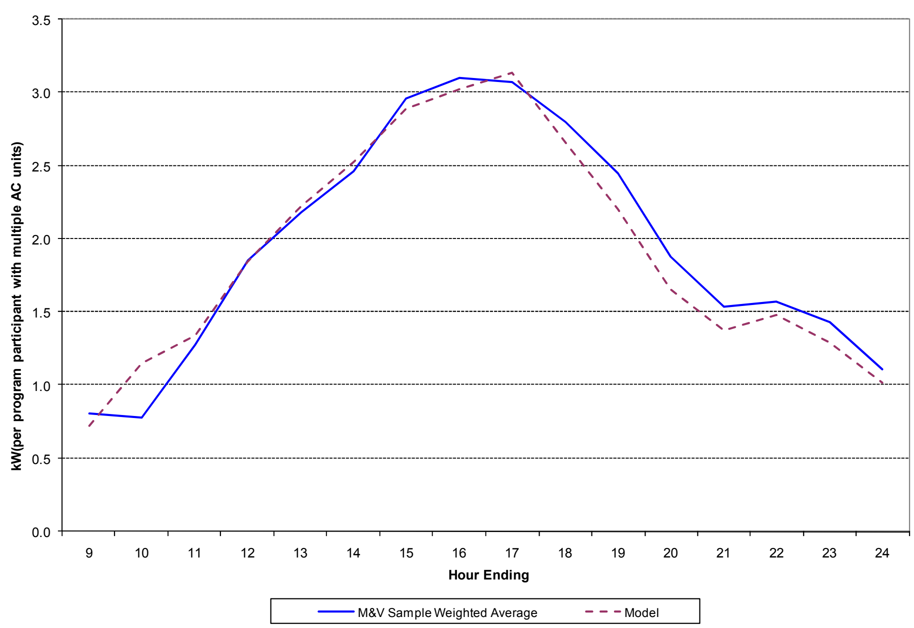
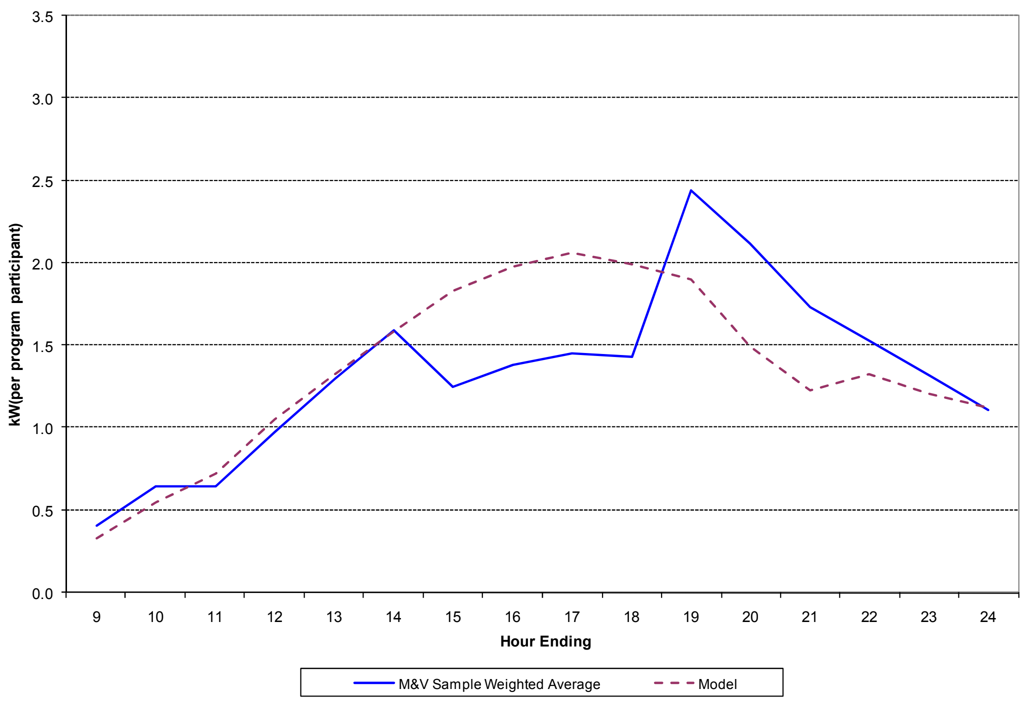


Figure 2-12
Average Program Participant
August 19, 2009 – Cycling at 50% from 2 to 6 PM
(Raleigh 98°F, Asheville 84°F, Wilmington 90°F)



The estimates for August 19 are presented in Figure 2-12. Load impact estimates are 0.6 kW (+/- 0.2 in the first hour and +/- 0.1 in all others).

It is estimated that 9 percent of the AC units enrolled in EnergyWise were not operating at the time of the event. This is illustrated in Table 2-2. Since these impact estimates are an average per unit, all participating units are taken into account, whether they operate at the time of the event or not.

Figure 2-13 and Figure 2-14 illustrate the estimates for the event of August 19 for participants with one AC unit and with multiple units, respectively.

Figure 2-13
Average Program Participant with One AC Unit
August 19, 2009 – Cycling at 50% from 2 to 6 PM
(Raleigh 98°F, Asheville 84°F, Wilmington 90°F)

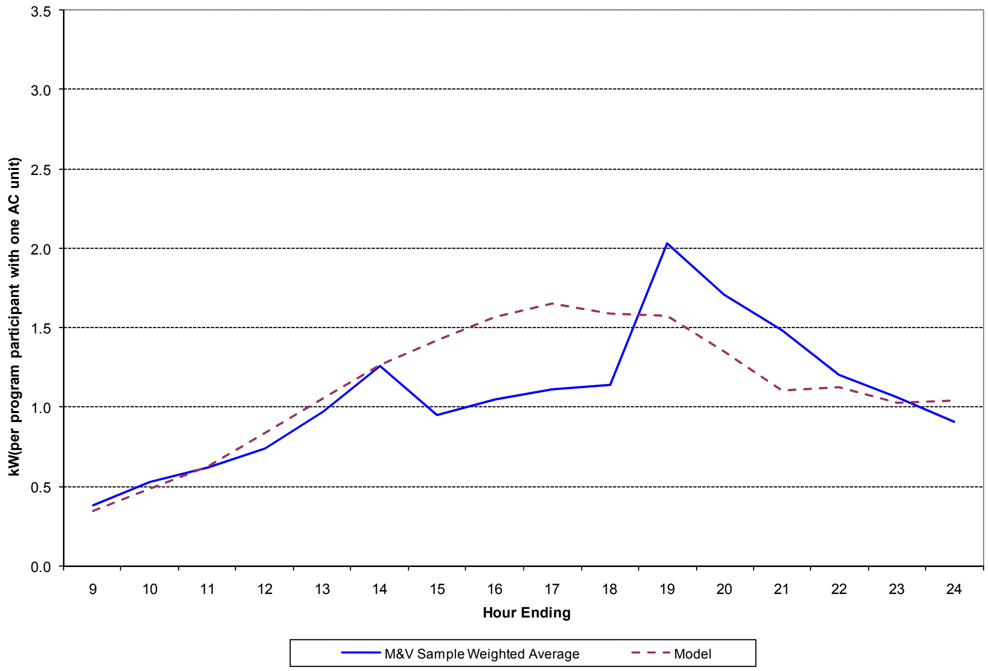
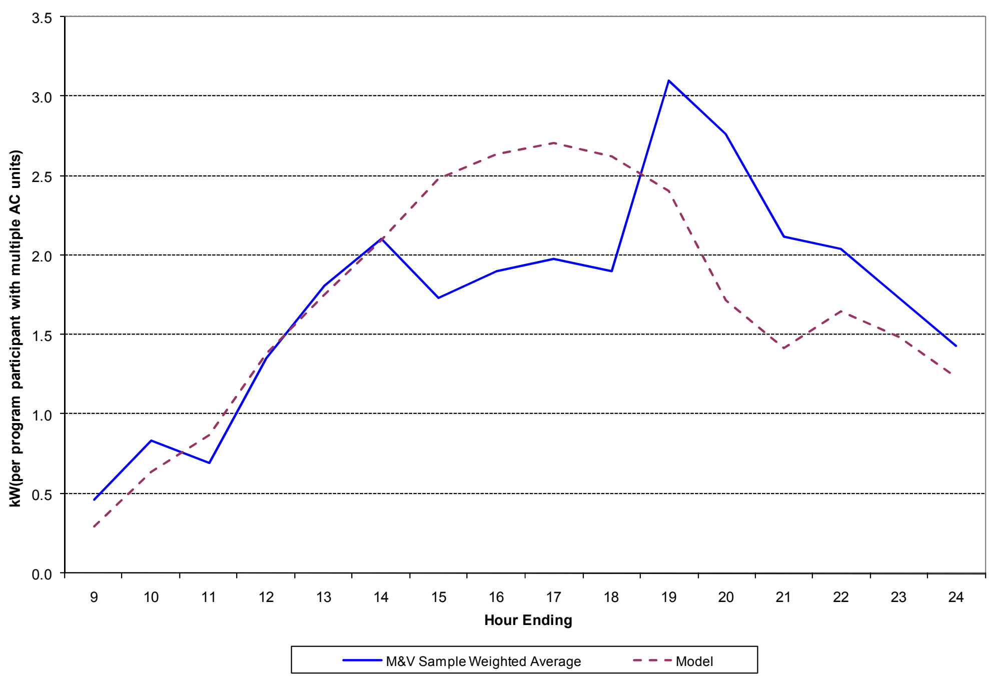


Figure 2-14
Average Program Participant with Multiple AC Units
August 19, 2009 – Cycling at 50% from 2 to 6 PM
(Raleigh 98°F, Asheville 84°F, Wilmington 90°F)



August 20 is the only event of the season that is "shaped to peak" where the first and last hours of the event cycle at a lower percent (in this case, 50%) than the two middle hours (in this case, 75%).

This event was conducted in Raleigh and Wilmington only. However, the estimates presented are for the entire program. This means that the average load impacts for the regions that participated are higher than those shown in this figure.

For this event, the estimates of load impacts are 0.4 kW in the first event hour (50% cycling), 0.8 and 0.9 kW for the second and third event hours (75% cycling during hours ending 4 and 5 PM), and 0.3 kW during the last hour of the event (50% cycling during hour ending 6 PM). The 90% confidence interval is 0.1 kW for the first and last hours of the event, and 0.2 kW for the two middle hours.

It is estimated that 14 percent of the AC units enrolled in EnergyWise were not operating at the time of the event. This is illustrated in Table 2-2. Since these impact estimates are an average per unit, all participating units are taken into account, whether they operate at the time of the event or not.

Figure 2-15
Average Program Participant - August 20, 2009
Cycling at 50% during hours ending 3 and 6 PM, and at 75% during hours ending 4 and 5 PM in Raleigh and Wilmington only. Chart reflects all program participants.
(Raleigh 92°F, Asheville 82°F, Wilmington 91°F)

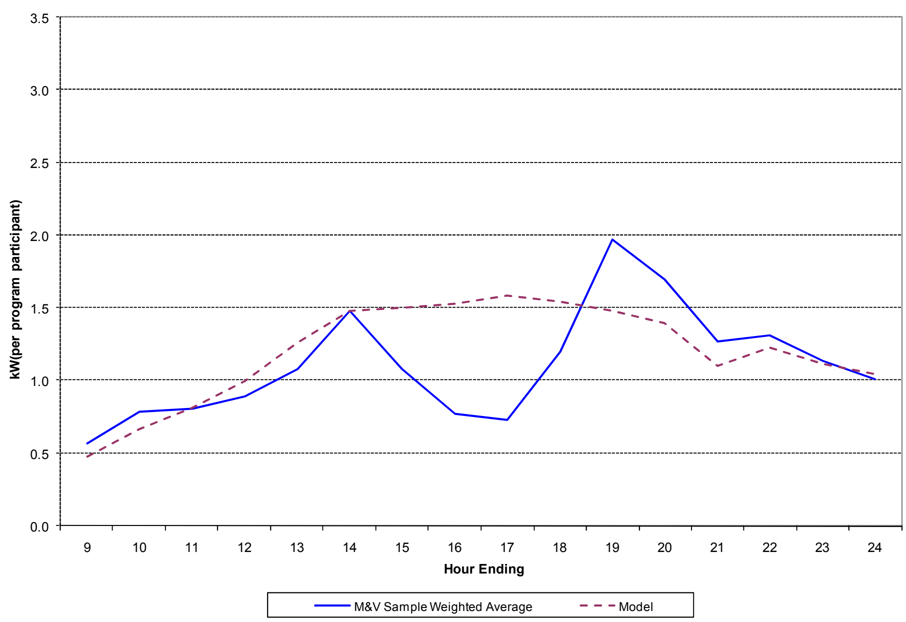


Figure 2-16
Average Program Participant with One AC Unit - August 20, 2009
Cycling at 50% during hours ending 3 and 6 PM, and at 75% during hours ending 4 and 5 PM in Raleigh and Wilmington only. Chart reflects all program participants.
(Raleigh 92°F, Asheville 82°F, Wilmington 91°F)

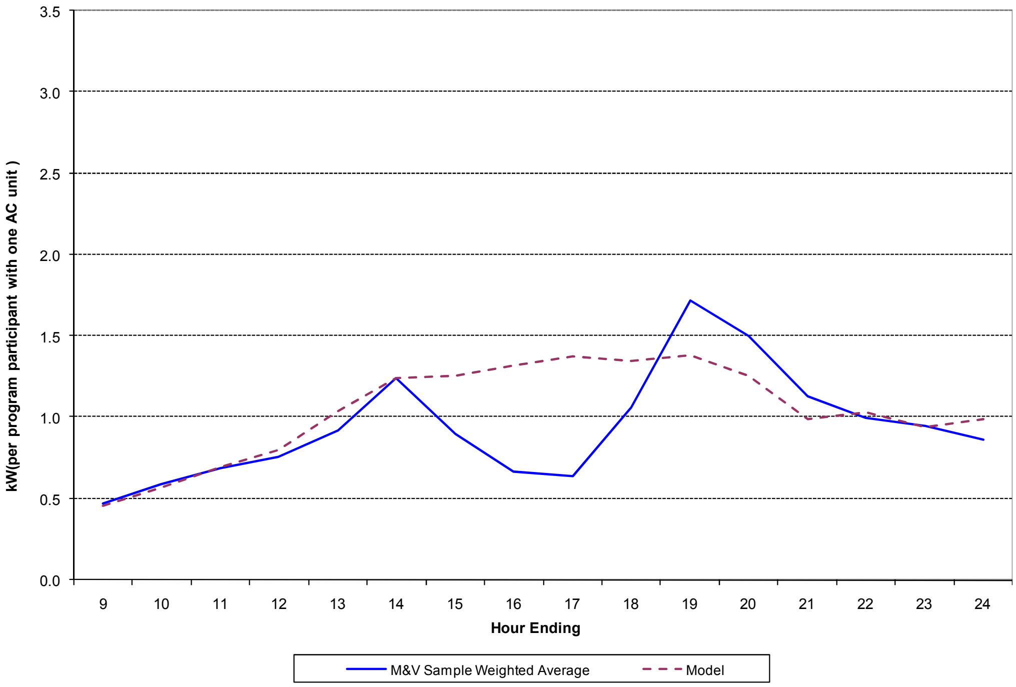
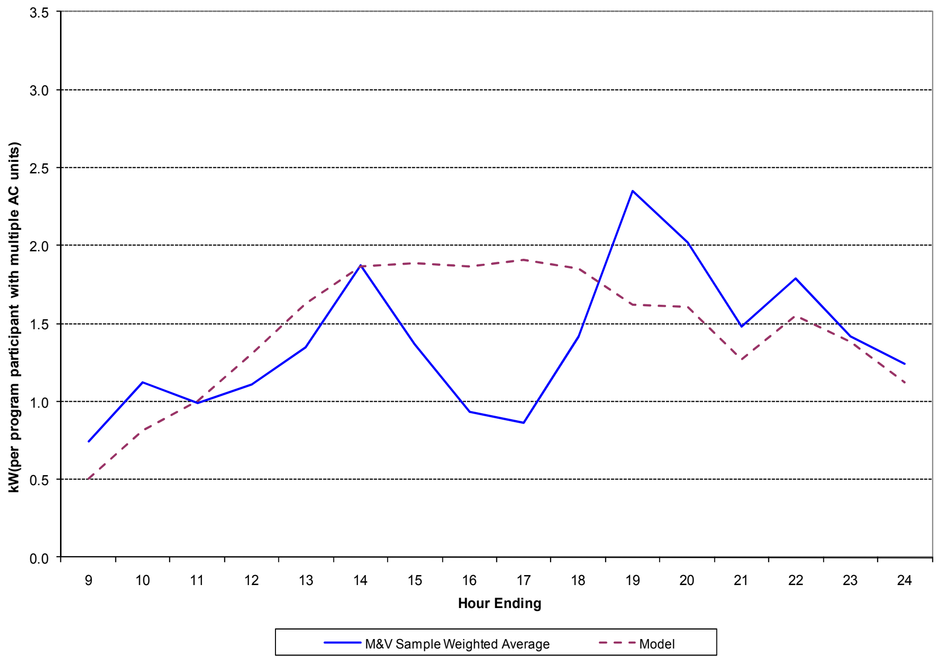


Figure 2-17
Average Program Participant with Multiple AC Units - August 20, 2009
Cycling at 50% during hours ending 3 and 6 PM, and at 75% during hours ending 4 and 5 PM in Raleigh and Wilmington only. Chart reflects all program participants. (Raleigh 92°F, Asheville 82°F, Wilmington 91°F)



2.2 Event Overrides

Accurate estimates of event override are critical to direct load control programs because of the potential detrimental impact on the amount of demand response that the program can provide. EnergyWise limits the magnitude of these effects by allowing only two overrides per season. Since 2009 was the first year of operation for the program, it is too early to estimate the long term override rates of the program. Changes in the demographics of program participants and warmer weather will have an effect on these rates.

The first two events of 2009 involved all program participants. These were helpful to gain some insight on the response of all program participants to a control event, and not that of the sample only.

Five program participants requested to override the event of August 5, and three participants did the same for August 10. These are very small numbers, especially when compared to the number of program participants that requested event overrides on days when there was no control event.

It is common for DLC programs to receive override requests on days when there is no event. These requests are typically from customers that feel that their air conditioning is insufficient on hot or humid days, and attribute that to a control event, even if there was none. On August 6 there were three override requests from program participants not in the sample, and one override request on August 7 – neither of these two dates were event days. Only two M&V sample participants requested event overrides in 2009.

3. Non-Response Rates

A non-responsive unit is defined as a participating air conditioner that was operating at the time of the event, that did not reduce its load as a result of the event, and that does not have a record of an event opt-out.

The two most common reasons for non-responsive units are signal problems (permanent or temporary) and DLC device malfunction.

To quantify non-responsive units, KEMA visually examined the load data for each air conditioner in the sample, on event days and on the days before and after each event day. The event day load of each sample air conditioner was classified into five categories:

1. No control (unit clearly did not respond to the curtailment)
2. Control (unit clearly reduced load in response to the curtailment)
3. The unit's response status cannot be determined from the visual inspection of the load data
4. The unit was not operating during the event
5. The curtailment does not apply to this unit (for example, a load control event in Raleigh does not apply to a unit in Wilmington)

Examples of the load data for AC units in the first three categories are presented in Appendix C.

For the purposes of estimating the non-response rate, units where the response status could not be determined from the load data are deemed to be responsive.

Estimated non-response rates are presented in the second column of Table 2-2. Non-response rates range between 0 and 2 percent. Response rates are as high as 90 percent on the hottest days of the season. The balance is units that were not operating on the day of the event, and for a couple of events, for units that are not in the areas of events that were geographically limited.

Table 2-1
EnergyWise Summer Non-Response Rates
Summer of 2009

EnergyWise Event Dates	Percent of non-responsive units	Percent of responsive units	Percent of units with no usage at the time of the event	Percent of units in areas where no control was implemented	Total
8/5/2009	0%	87%	13%	0%	100%
8/10/2009	1%	89%	10%	0%	100%
8/19/2009	1%	90%	9%	0%	100%
8/20/2009	0%	86%	14%	0%	100%
8/27/2009	0%	90%	10%	0%	100%
8/28/2009	0%	67%	12%	20%	100%
9/14/2009	0%	60%	40%	0%	100%
9/24/2009	2%	75%	23%	0%	100%
9/25/2009	0%	6%	9%	84%	100%
9/28/2009	2%	40%	57%	0%	100%

4. Load Impact Projections

This section details the load impact projections that were estimated for the EnergyWise summer program under different scenarios.

4.1 Load Impact Projections Scenario Parameters

Load impact projections were developed for all combinations of the parameters listed in Table 3-1. These parameters are described below.

- **Weather Year** describes the two temperature scenarios employed in the load impact projections: *typical* for a year where the temperatures are in the median of the temperatures observed in the last 10 years, and *extreme*, for the highest temperatures observed in the same period.
- **Region** refers to the three geographical areas in which the EnergyWise Program operates in North Carolina.
- **Number of Air Conditioners at the Premise** has values of Single (one AC), Multiple (two or more ACs) and Average (1.4 AC units per participant, which was the average number of units per participant in the summer of 2009).
- **Percent Cycling** is the percent of the AC's duty cycle that is interrupted using an adaptive algorithm.
- **Adaptive Cycling Algorithm** is the type of adaptive algorithm used in the event. *Ideal Control Day* (ICD) utilizes information about the AC's duty cycle on days when the DLC devices were signaled to collect such information; *Prior Hour* utilizes information regarding the AC's use in the hour prior to the start of the event.
- **Load Impact Adjustment** is a factor applied to the load impact projection to account for rate of non-response and other deviations from "perfect" DLC device performance[2]. It includes a "non-response" option (for units that did not respond to the event), an "empirical factor" option (which combines non-response with imperfect DLC device performance) and a "no adjustment" option, representing ideal performance – with a 0 percent non-response rate and perfect use of the adaptive algorithms.

[2] There are a number of valid reasons why DLC device performance is, on average, not "perfect". These are discussed in Section 3.2.6 Load Impact Adjustment Effect.

Table 3-1
EnergyWise Summer Load Impact Projection Scenario Parameters

Weather Year	Region	Number of Air Conditioners at the Premise	Percent Cycling	Adaptive Cycling Algorithm	Load Impact Adjustment
1. Typical 2. Extreme	1. Asheville 2. Raleigh 3. Wilmington	1. Single 2. Multiple	1. 50% 2. 75% 3. 100%	1. Ideal Control Day 2. Prior hour	1. Empirical Factor 2. Non-Response Adjustment 3. No Adjustment

The following subsection includes examples of some of these scenarios, and discussions of the influence of the different parameters in the corresponding load impacts.

4.2 Examples of Load Impact Projection Scenarios

4.2.1 Weather Year Effect

The scenarios include two types of weather year: *Typical* and *Extreme*. This section illustrates the influence of the weather year parameter in the load impact projections.

Figure 3-1 and Figure 3-2 show the load impact for an EnergyWise residential customer in Raleigh, with multiple air conditioners, with an event that controls the air conditioners at 50 percent using the ICD algorithm, on the hottest day of the year. The load impacts are adjusted by the non-response factor, which is very low – about 0.5 percent – in the summer.

The maximum daily temperature in Raleigh in this scenario is expected to be about 96°F in a typical year and about 104°F during an extreme year.

The load impacts are 1.2 to 1.5 kW per hour for the typical year, and 1.8 to 2.0 kW per hour for the extreme year, or about 30 to 45 percent larger in the extreme year than in the typical year.

Figure 3-1 Central Air Conditioning Load Impact Projection
Region: Raleigh | **Weather Year: Typical** | **Number of Units: Multiple**
Control Percent: 50% | **Control Algorithm: ICD** | **Load Impact Adjustment: Non-Response**

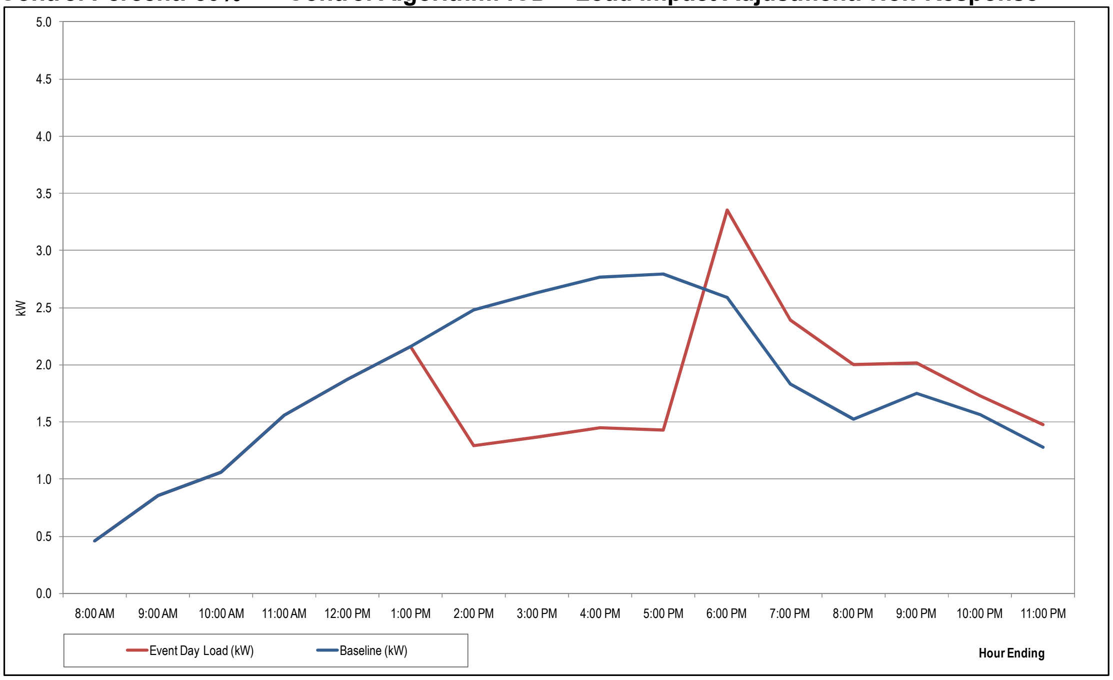
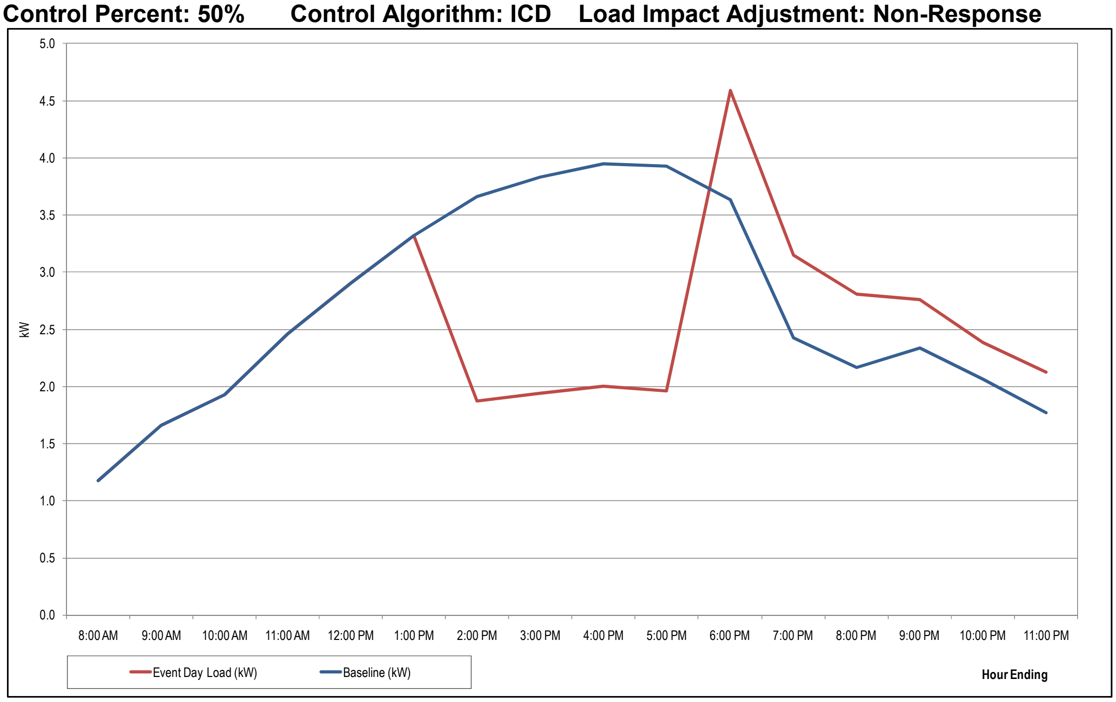


Figure 3-2 Central Air Conditioning Load Impact Projection
Region: Raleigh | **Weather Year: Extreme** | **Number of Units: Multiple**
Control Percent: 50% | **Control Algorithm: ICD** | **Load Impact Adjustment: Non-Response**



4.2.2 Region Effect

The scenarios include the three regions in which the EnergyWise summer program is operating in North Carolina: Asheville, Raleigh, and Wilmington. This section illustrates the influence of the Region parameter in the load impact projections.

Table 3-2 and Figure 3-3 thru Figure 3-5 show the load impact projections for an EnergyWise residential customer with a single air conditioner, during an event that controls the air conditioner at 75 percent using the ICD algorithm, on the hottest day in a typical weather year. The hottest day of the typical year is in August for Asheville and Wilmington, and in July for Raleigh. The load impacts are adjusted by the non-response factor, which is about 0.5 percent.

The second heading row of Table 3-2 shows the maximum temperature of the day in each region. The load impacts range from 0.8 to 1.1 kW in Asheville, 1.2 to 1.4 kW in Raleigh, and 1.3 to 1.6 kW in Wilmington.

Table 3-2 Central Air Conditioning Load Impact Projections by Region
Weather Year: Typical **Number of Units: Single**
Control Percent: 75% **Control Algorithm: ICD**
Load Impact Adjustment: Non-Response

Hour Ending	Asheville	Raleigh	Wilmington
	92°F	96°F	98°F
2:00 PM	0.81	1.16	1.36
3:00 PM	0.98	1.27	1.47
4:00 PM	1.10	1.38	1.55
5:00 PM	1.14	1.35	1.54
6:00 PM	-0.52	-0.61	-0.67
7:00 PM	-0.40	-0.48	-0.54
8:00 PM	-0.36	-0.45	-0.50
9:00 PM	-0.24	-0.32	-0.38
10:00 PM	-0.19	-0.26	-0.32
11:00 PM	-0.20	-0.28	-0.34

Figure 3-3 Central Air Conditioner Load Impact Projection

Region: Asheville | **Weather Year: Typical** | **Number of Units: Single**
Control Percent: 75% | **Control Algorithm: ICD** | **Load Impact Adjustment: Non-Response**

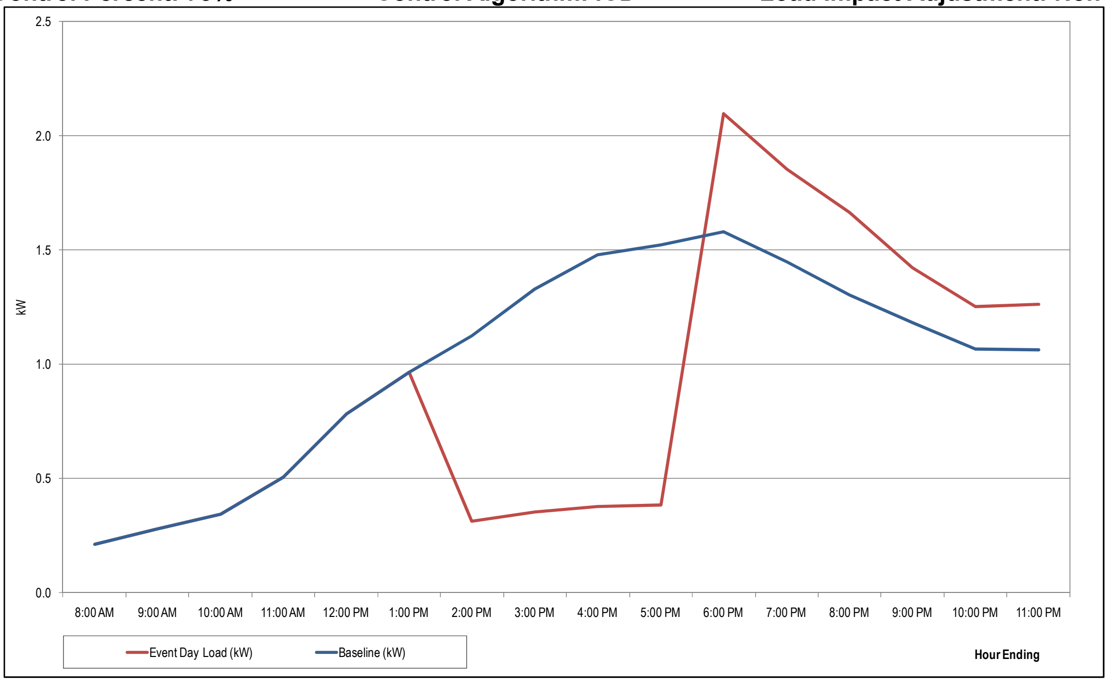


Figure 3-4 Load Impact Projection

Region: Raleigh | **Weather Year: Typical** | **Number of Units: Single**
Control Percent: 75% | **Control Algorithm: ICD** | **Load Impact Adjustment: Non-Response**

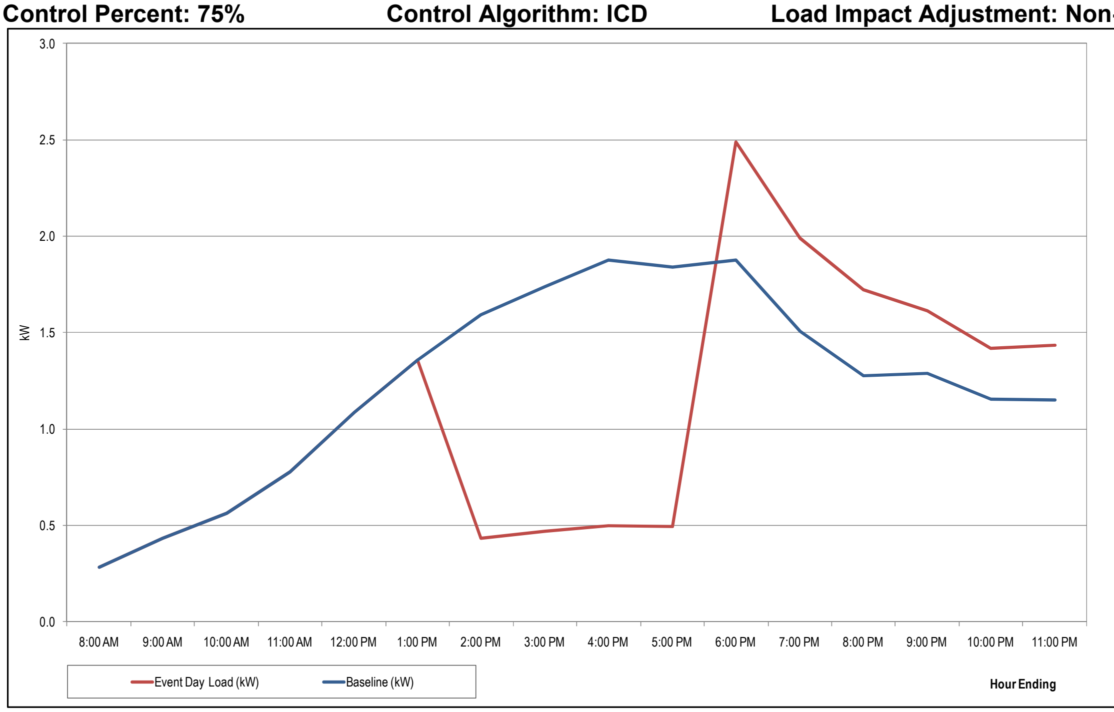
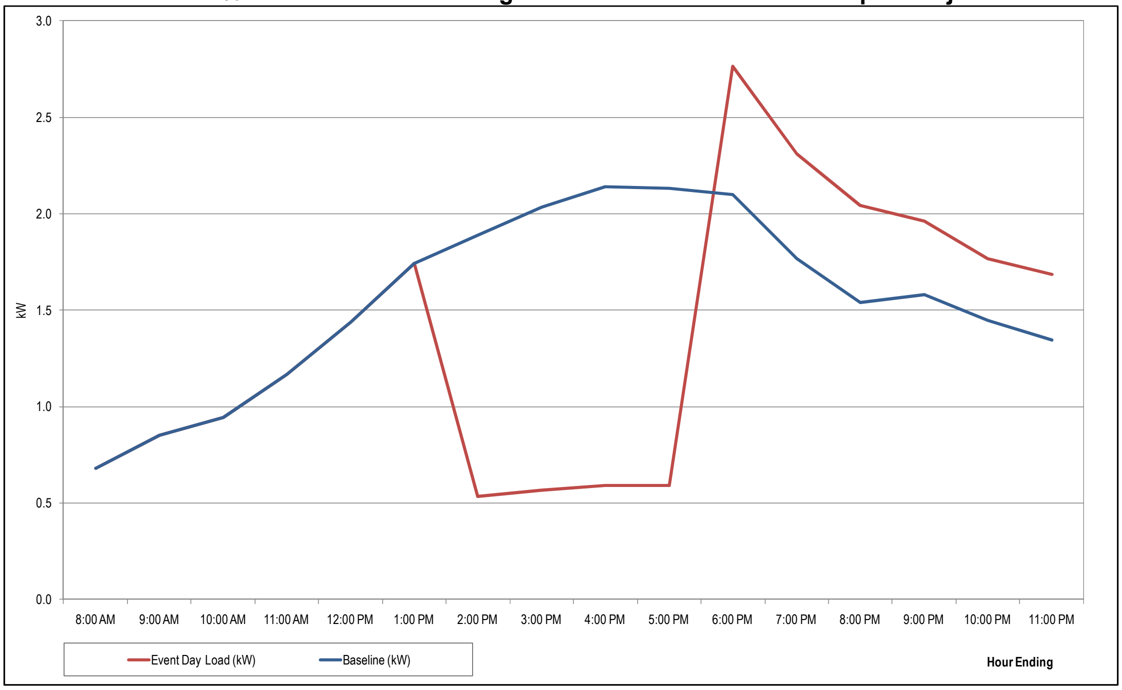


Figure 3-5 Load Impact Projection
Region: **Wilmington** | **Weather Year: Typical** | **Number of Units: Single**
Control Percent: 75% | **Control Algorithm: ICD** | **Load Impact Adjustment: Non-Response**



4.2.3 Number of Air Conditioners at the Premise Effect

The choices for Number of Air Conditioners at the Premise include one air conditioner and multiple air conditioners. This section illustrates the influence of the Number of Air Conditioners parameter in the load impact projections.

Figure 3-6 and Figure 3-7 show the load impact projections for an EnergyWise residential customer in the Wilmington area, during an event that controls the air conditioner at 100 percent, on the hottest day of the year, in an extreme weather year. At 100 percent control, both the non-response and empirical factor options produce the same estimates, and both the ICD and the prior hour algorithms also produce the same estimates.

In these scenarios, the maximum daily temperature is 99°F. The maximum load impacts are 1.9 kW and 3 kW, for participants with single and multiple air conditioners, respectively.

Table 3-3 displays the load impacts and snapback for each of the three regions, with a different number of air conditioners for each one.

Table 3-3 Central Air Conditioner Load Impact Projections by Region for Single/Multiple Air Conditioners at the Premise

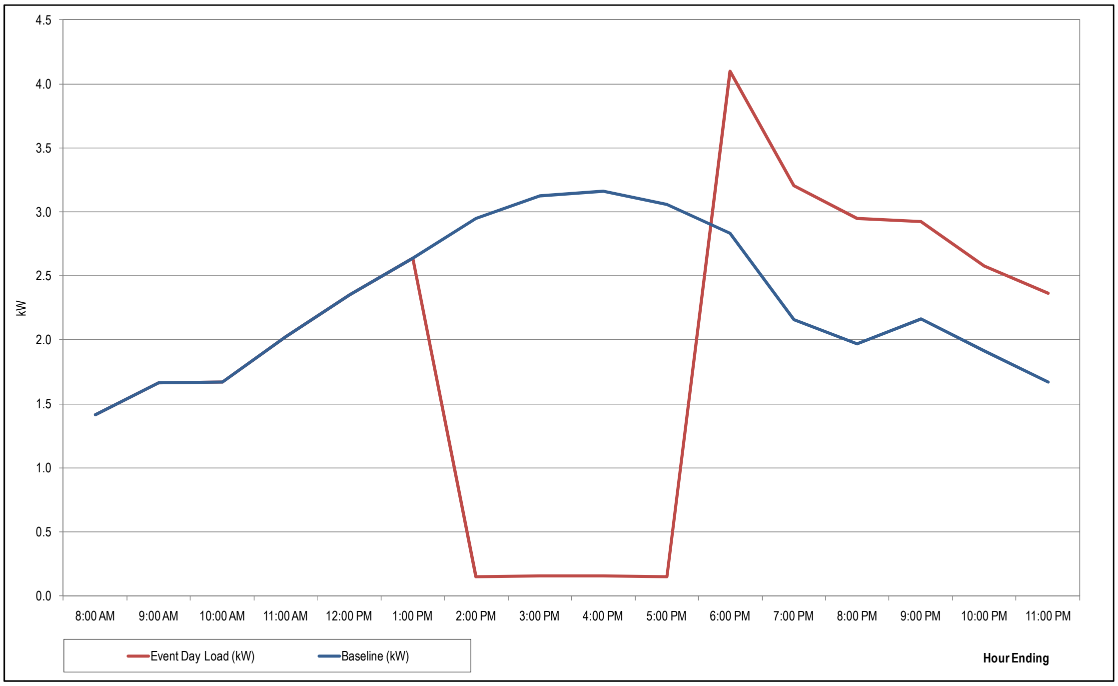
Weather Year: Extreme **Control Percent: 100%**

	Asheville		Raleigh		Wilmington	
Hour Ending	Single	Multiple	Single	Multiple	Single	Multiple
2:00 PM	1.06	1.50	2.16	3.48	1.87	2.80
3:00 PM	1.30	1.84	2.20	3.64	1.96	2.97
4:00 PM	1.40	2.00	2.29	3.75	2.04	3.01
5:00 PM	1.44	2.02	2.24	3.73	1.97	2.91
6:00 PM	-0.61	-0.94	-0.90	-1.48	-0.81	-1.26
7:00 PM	-0.49	-0.72	-0.75	-1.22	-0.69	-1.05
8:00 PM	-0.45	-0.65	-0.71	-1.14	-0.65	-0.98
9:00 PM	-0.33	-0.43	-0.58	-0.92	-0.53	-0.76
10:00 PM	-0.27	-0.33	-0.52	-0.81	-0.48	-0.66
11:00 PM	-0.29	-0.37	-0.54	-0.84	-0.50	-0.69

Figure 3-6 Central Air Conditioner Load Impact Projection

Region: Wilmington **Weather Year: Extreme** **Number of Units: Single**
Control Percent: 100%

Figure 3-7 Central Air Conditioner Load Impact Projection
Region: Wilmington **Weather Year: Extreme** **Number of Units: Multiple**
Control Percent: 100%



4.2.4 Percent Cycling Effect

The choices for Percent Cycling include 50 percent, 75 percent, and 100 percent. This section illustrates the influence of percent cycling on the load impact projections.

Table 3-4 and Figure 3-8 thru Figure 3-10 illustrate the load impacts of an EnergyWise event at different cycling levels during the hottest day of an extreme year in the Raleigh area[3], for participants with multiple air conditioners. Impacts at 4 PM vary between 1.4 kW at 50 percent cycling to 3.8 kW at 100 percent cycling.

[3] The hottest day of the extreme year in Raleigh is in the month of August. The maximum temperature of the day is 104°F, and the average from 9 AM to midnight is 95°F.

Table 3-4 Central Air Conditioner Load Impact Projections at Different Levels of Cycling
Region: Raleigh **Weather Year: Extreme** **Number of Units: Multiple**
Control Algorithm: ICD **Load Impact Adjustment: Empirical Factor**

Hour Ending	50 %	75 %	100 %
2:00 PM	1.37	2.02	3.48
3:00 PM	1.53	2.10	3.64
4:00 PM	1.43	2.28	3.75
5:00 PM	1.31	2.16	3.73
6:00 PM	-0.81	-1.03	-1.48
7:00 PM	-0.58	-0.79	-1.22
8:00 PM	-0.50	-0.71	-1.14
9:00 PM	-0.29	-0.49	-0.92
10:00 PM	-0.18	-0.39	-0.81
11:00 PM	-0.22	-0.42	-0.84

Figure 3-8 Central Air Conditioner Load Impact Projection
Region: Raleigh **Weather Year: Extreme** **Number of Units: Multiple**
Control Percent: 50% **Control Algorithm: ICD** **Load Impact Adjustment: Empirical Factor**

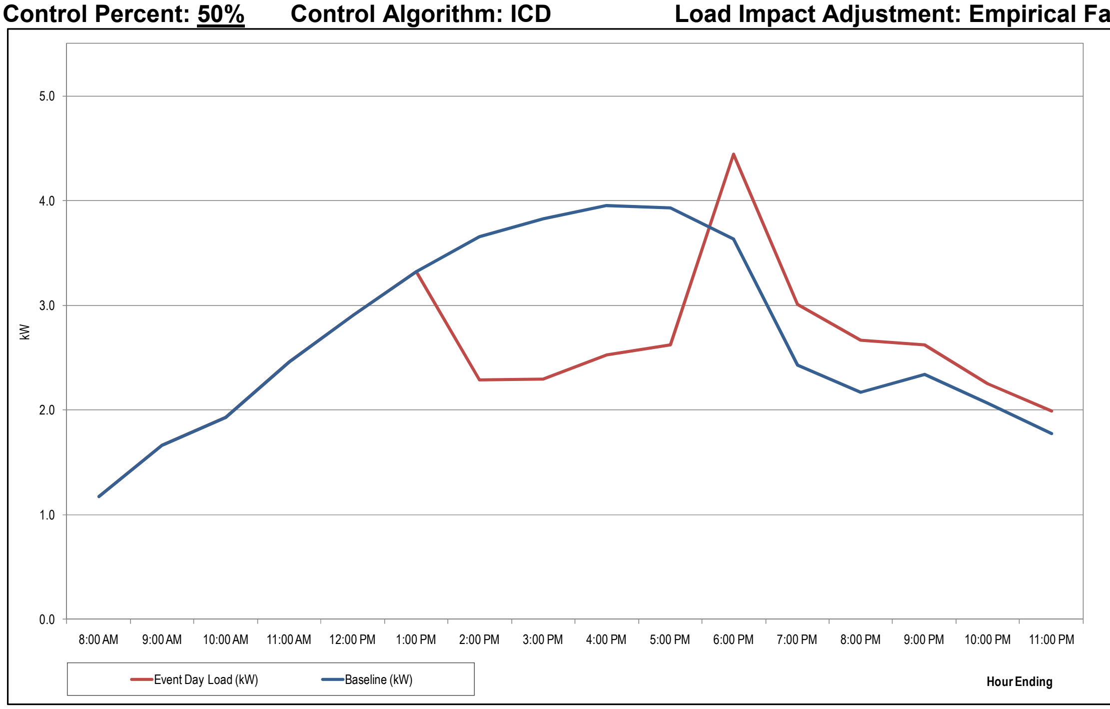


Figure 3-9 Central Air Conditioner Load Impact Projection

Region: Raleigh **Weather Year: Extreme** **Number of Units: Multiple**
Control Percent: 75% **Control Algorithm: ICD** **Load Impact Adjustment: Empirical Factor**

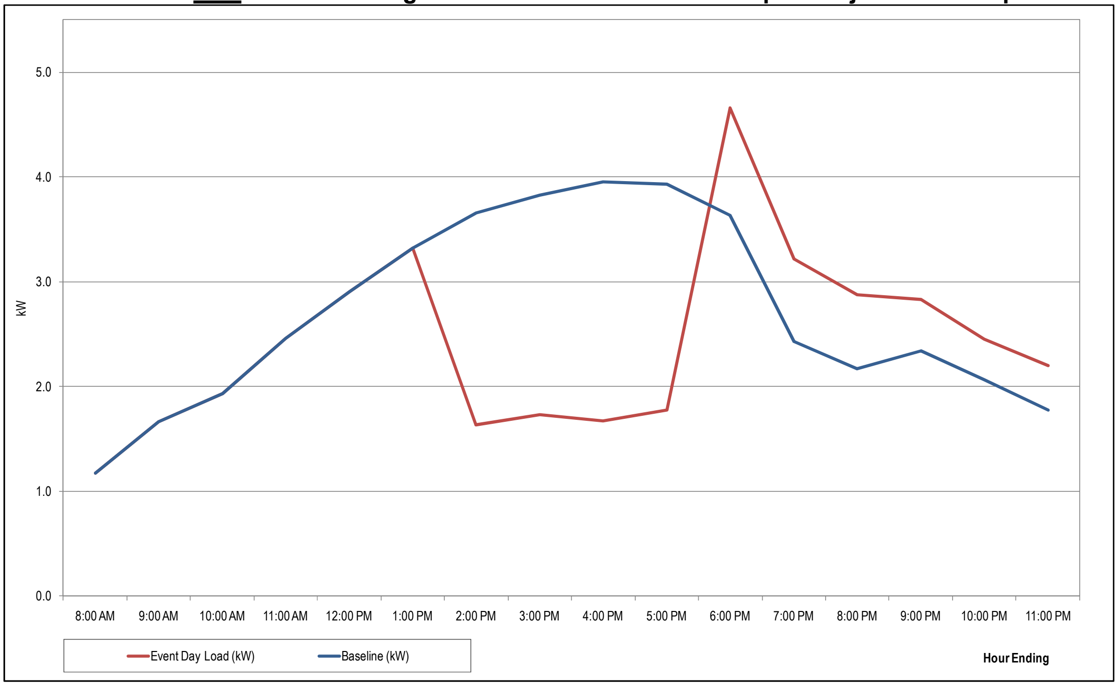
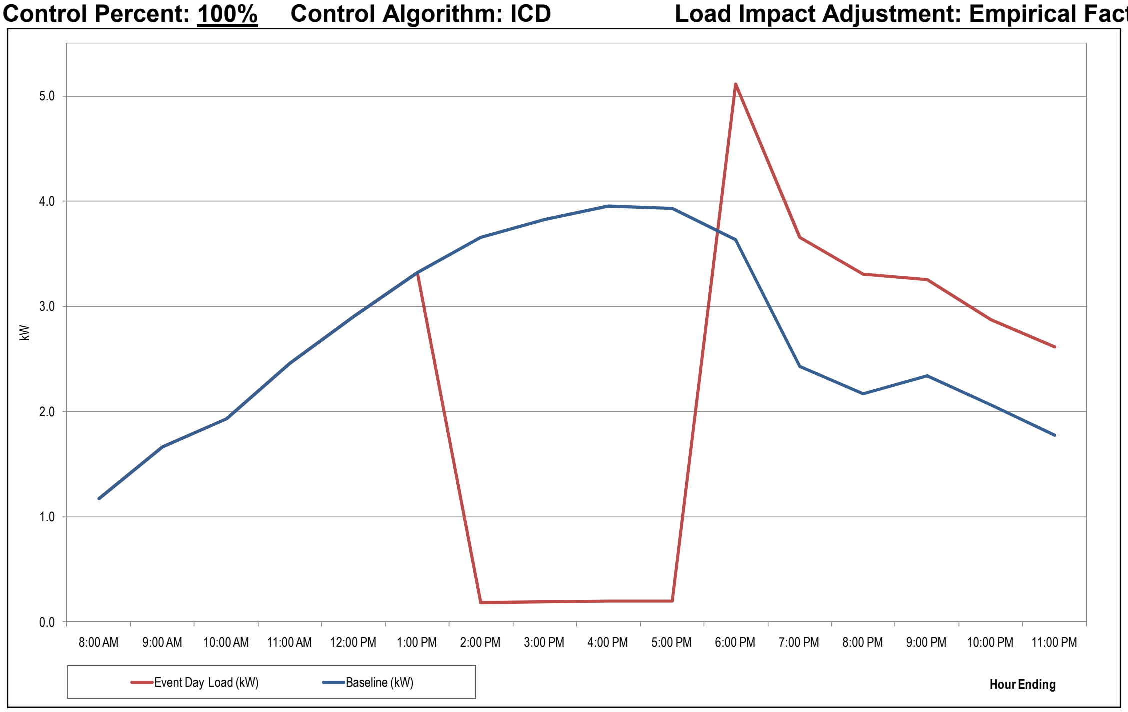


Figure 3-10 Central Air Conditioner Load Impact Projection

Region: Raleigh **Weather Year: Extreme** **Number of Units: Multiple**
Control Percent: 100% **Control Algorithm: ICD** **Load Impact Adjustment: Empirical Factor**



4.2.5 Adaptive Cycling Algorithm Effect

The choices for Adaptive Cycling Algorithm available in the summer program include Ideal Control Day (ICD) and Prior Hour. This section illustrates the influence of the adaptive algorithm in the load impact projections.

The ICD algorithm produces higher savings than the Prior Hour algorithm. The following examples are for a participant with a single air conditioner in the Wilmington region, on the hottest day in an extreme year. A 75 percent control produces a maximum load impact of 1.2 kW with the ICD algorithm, and 1.1 kW with the Prior Hour algorithm. The average load impact, over all of the event's four hours, is 1.1 kW with the ICD algorithm and 0.9 kW with the Prior Hour algorithm.

Figure 3-11 Load Impact Projection
Region: Wilmington **Weather Year: Extreme** **Number of Units: Single**
Control Percent:75% **Control Algorithm: ICD** **Load Impact Adjustment: Empirical Factor**

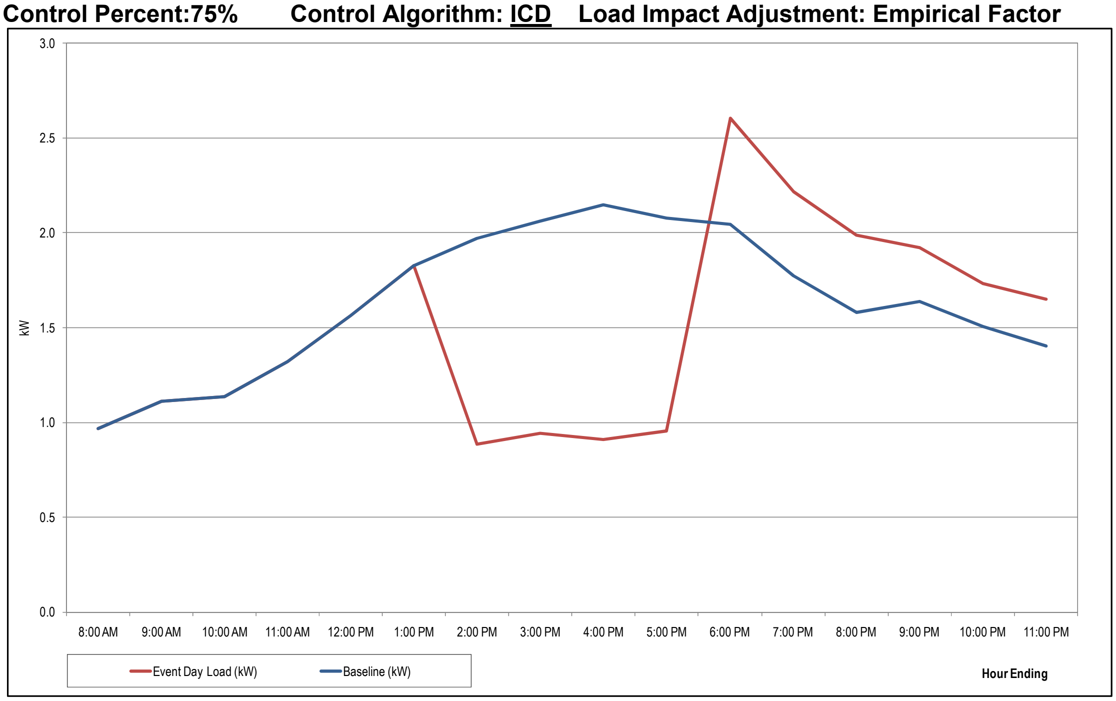
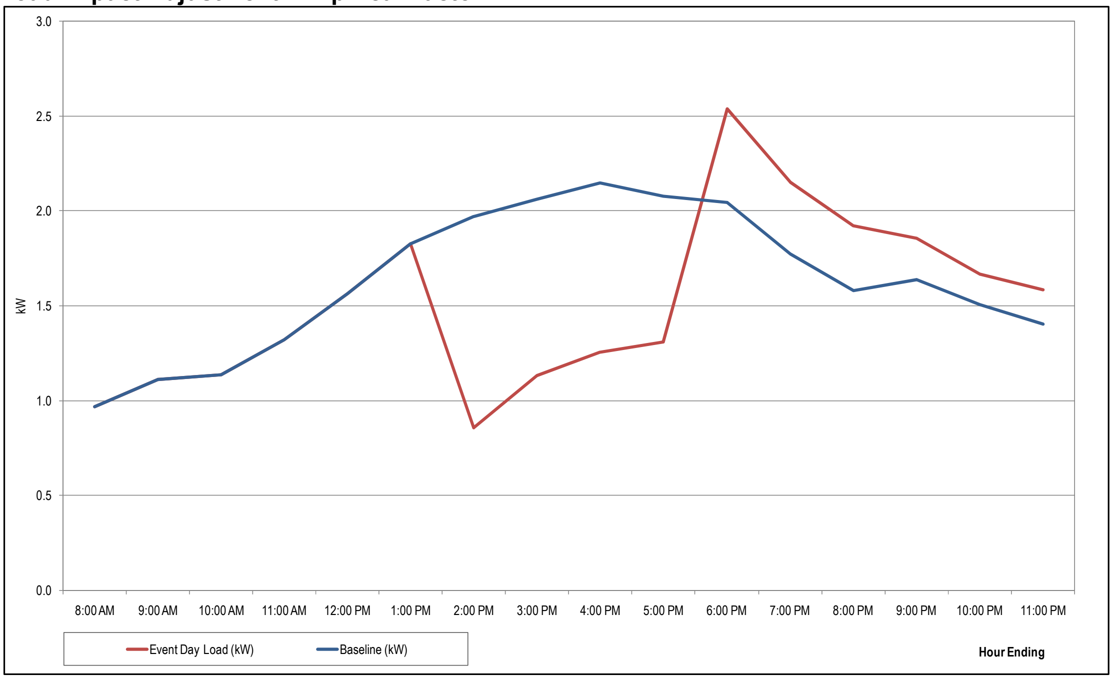


Figure 3-12 Load Impact Projection

Region: Wilmington **Weather Year: Extreme** **Number of Units: Single**
Control Percent:75% **Control Algorithm: Prior Hour** **Weekday Type: August Hottest**
Load Impact Adjustment: Empirical Factor



4.2.6 Load Impact Adjustment Effect

Load Impact Adjustment is a factor applied to the load impact projection to account for rate of non-response and other deviations from "perfect" DLC device performance.

There are a number of valid and expected reasons why DLC device performance is, on average, not "perfect". Examples of these reasons are:

- In the case of ICDs, not all devices have the same days, or even number of days, in memory
- Devices may be programmed to make exceptions to the use of ICD information in certain circumstances

In addition, DLC device manufacturers employ proprietary algorithms, and the nuances of their performance are not available to the load modeling team.

There are three choices for the load impact adjustment effect:

- "Non-Response Adjustment" reflects the percent of non-responsive units that was estimated with 2009 data – about 0.5 percent.
- "Empirical Factor" represents a combination of the non-response adjustment described above, and the imperfect performance of the DLC devices.
- "No Adjustment" represents ideal performance – with a 0 percent non-response rate and perfect performance of the adaptive algorithms. This scenario is unattainable in actual program operation, but it is a useful gauge for comparison to other scenarios.

Table 3-5 illustrates the expected differences in load impacts for the hottest day in an extreme year, for a Raleigh participant with a single air conditioner and an event with 50 percent control.

Average impacts for the empirical factor scenario are 35 percent lower than for the non-response only scenario.

Table 3-5 Central Air Conditioner Load Impact Projections for Different Levels of Adjustment

Region: Raleigh **Weather Year: Extreme** **Number of Units: Single**
Control Percent: 50% **Control Algorithm: ICD**

Hour Ending	104°F		
	Empirical Factor	Non-Response Only	No Adjustment
2:00 PM	0.87	1.13	1.19
3:00 PM	0.92	1.14	1.19
4:00 PM	0.87	1.18	1.25
5:00 PM	0.77	1.16	1.22
6:00 PM	-0.48	-0.57	-0.59
7:00 PM	-0.35	-0.44	-0.46
8:00 PM	-0.31	-0.39	-0.41
9:00 PM	-0.19	-0.27	-0.29
10:00 PM	-0.13	-0.21	-0.23
11:00 PM	-0.15	-0.24	-0.25

4.2.7 Comparison of Central Air Conditioning Load Impact Projections to Deemed Savings

Table 3-6 includes the program design assumptions ("PEC Deemed Savings") regarding central air conditioner impacts, and the estimated projections at 50 percent cycling between 2 and 6 PM, for program participants with one AC unit. Table 3-7 shows the same for participants with multiple units. These tables show that participants with multiple units would meet deemed savings at a 50 percent level of cycling.

Table 3-8 through Table 3-11 present the same comparisons at 75 and 100 percent cycling. At 75 percent cycling, the program meets deemed savings with single-unit households in Raleigh and Wilmington in extreme hot years. . At 100 percent cycling, all combinations of region and number of units meet or exceed deemed savings (except for single-unit participants in Asheville in a typical year.)

The estimated load impacts in these tables correspond to the following scenario:

1. The load impact projections selected are for days with the maximum load impact in the Raleigh region.
2. Event is from 2 to 6 PM
3. Rate of non-response is about 0.5 percent
4. The "Extreme" weather year is the hottest of ten years. The "Typical" weather year is defined as the median year based on the temperatures of the three hottest days of each of the ten years. Half of the years are colder than "typical", and the other half are hotter.

Table 3-6
Deemed Savings Vs Central Air Conditioning Regional Load Impact Projections
Participants with Single AC Units – 50 Percent Cycling

Weather Type	Maximum Daily Temperature (°F)	Average Load Impact (kW)	Total Load Impact (kWh)	Average Snapback (kW)	Total Snapback (kWh)	Total Savings (kWh)
Deemed Savings						
		1.21				0.90
Asheville						
Extreme	92	0.55	2.22	0.18	1.10	1.12
Typical	89	0.45	1.81	0.15	0.90	0.91
Raleigh						
Extreme	104	0.86	3.43	0.27	1.61	1.82
Typical	96	0.67	2.69	0.22	1.30	1.38
Wilmington						
Extreme	96	0.74	2.96	0.24	1.44	1.53
Typical	91	0.60	2.38	0.20	1.19	1.19

Table 3-7
Deemed Savings Vs Central Air Conditioning Regional Load Impact Projections
Participants with Multiple AC Units – 50 Percent Cycling

Weather Type	Maximum Daily Temperature (°F)	Average Load Impact (kW)	Total Load Impact (kWh)	Average Snapback (kW)	Total Snapback (kWh)	Total Savings (kWh)
Deemed Savings						
		1.21				0.90
Asheville						
Extreme	92	0.80	3.20	0.27	1.60	1.60
Typical	89	0.64	2.54	0.21	1.28	1.26
Raleigh						
Extreme	104	1.41	5.64	0.43	2.58	3.06
Typical	96	1.03	4.10	0.33	1.97	2.13
Wilmington						
Extreme	96	1.10	4.41	0.35	2.12	2.29
Typical	91	0.77	3.09	0.26	1.57	1.53

Table 3-8
Deemed Savings Vs Central Air Conditioning Regional Load Impact Projections (*)
Participants with Single AC Units – 75 Percent Cycling

Weather Type	Maximum Daily Temperature °F	Average Load Impact (kW)	Total Load Impact (kWh)	Average Snapback (kW)	Total Snapback (kWh)	Total Savings (kWh)
Deemed Savings						
		1.21				0.90
Asheville						
Extreme	92	0.79	3.16	0.25	1.53	1.64
Typical	89	0.64	2.55	0.20	1.23	1.32
Raleigh						
Extreme	104	1.3	5.21	0.40	2.39	2.82
Typical	96	1.00	3.98	0.31	1.88	2.10
Wilmington						
Extreme	96	1.14	4.56	0.36	2.17	2.40
Typical	91	0.93	3.70	0.30	1.80	1.90

Table 3-9
Deemed Savings Vs Central Air Conditioning Regional Load Impact Projections
Participants with Multiple AC Units – 75 Percent Cycling

Weather Type	Maximum Daily Temperature °F	Average Load Impact (kW)	Total Load Impact (kWh)	Average Snapback (kW)	Total Snapback (kWh)	Total Savings (kWh)
Deemed Savings						
		1.21				0.90
Asheville						
Extreme	92	1.13	4.51	0.36	2.18	2.33
Typical	89	0.90	3.59	0.29	1.73	1.85
Raleigh						
Extreme	104	2.14	8.56	0.64	3.83	4.73
Typical	96	1.53	6.11	0.48	2.86	3.26
Wilmington						
Extreme	96	1.70	6.79	0.53	3.20	3.59
Typical	91	1.23	4.92	0.40	2.40	2.53

Table 3-10
Deemed Savings Vs Central Air Conditioning Regional Load Impact Projections
Participants with Single AC Units – 100 Percent Cycling

Weather Type	Maximum Daily Temperature °F	Average Load Impact (kW)	Total Load Impact (kWh)	Average Snapback (kW)	Total Snapback (kWh)	Total Savings (kWh)
Deemed Savings						
		1.21				0.90
Asheville						
Extreme	92	1.30	5.2	0.41	2.45	2.76
Typical	89	1.05	4.18	0.32	1.95	2.23
Raleigh						
Extreme	104	2.22	8.89	0.67	4.01	4.88
Typical	96	1.67	6.70	0.52	3.09	3.61
Wilmington						
Extreme	96	1.96	7.85	0.61	3.67	4.18
Typical	91	1.60	6.38	0.51	3.04	3.34

Table 3-11
Deemed Savings Vs Central Air Conditioning Regional Load Impact Projections
Participants with Multiple AC Units – 100 Percent Cycling

Weather Type	Maximum Daily Temperature °F	Average Load Impact (kW)	Total Load Impact (kWh)	Average Snapback (kW)	Total Snapback (kWh)	Total Savings (kWh)
Deemed Savings						
		1.21				0.90
Asheville						
Extreme	92	1.84	7.37	0.57	3.44	3.93
Typical	89	1.46	5.84	0.45	2.71	3.13
Raleigh						
Extreme	104	3.65	14.6	1.07	6.41	8.19
Typical	96	2.58	10.31	0.78	4.7	5.61
Wilmington						
Extreme	96	2.92	11.68	0.9	5.41	6.27
Typical	91	2.15	8.59	0.68	4.06	4.53

5. Recommendations

The measurement and verification activities conducted in the summer of 2009 provide valuable information that can be used to potentially improve the future load impacts of PEC's EnergyWise program. Because this M&V study was conducted when the program had just kicked-off, and had a low number of enrolled participants in some of the regions, the follow-up M&V that is planned for the summer of 2011 is warranted and should provide the additional data needed to make a comprehensive assessment of future load impacts.

1. **Investigate options to reduce the level of snapback**. While snapback is at levels that are common for this type of program, an early event could push snapback into a time of day when the system is still facing high demands from customers. These may include a staggered release from direct load control, which would cause snapback to spread over several hours. However, it would also cause some program participants to be in control mode longer than others. The consequences of such release have to be explored carefully, and possibly paired with customer research.

2. **Maintain the non-response rate observed in the first stages of the program**. The summer program experienced very low rates of non-response in the summer of 2009. The same protocols that generated these results can continue to be observed to maintain this high level of performance. It is not uncommon to have some of these processes become laxer or more difficult to enforce as the program grows.

3. **Conduct further M&V activities with the following purposes:**

    a. **Understanding the load patterns and potential load impacts of program participants that are not first adopters**. There is substantial market research in the energy industry that proves that first adopters of a program such as EnergyWise tend to be different than those that join as the program matures. First adopters tend to be more focused on the environmental message of a program like this, and potentially more likely to tolerate discomfort.

    b. **Better understand the differences between the regions in the PEC service territory**. This was not possible at the time of the first M&V study because the program was recruiting and installing mostly in the Raleigh area.

Appendices

Appendix A: Methodology

This section describes the methodology employed in the load impacts measurement and verification (M&V) of the EnergyWise summer 2009 season. The M&V effort included the following elements:

1. Sample Design
2. Temperature Data Analysis for M&V Event Plan
3. Logging Equipment Installation
4. Load Data Preparation
5. Load Data Modeling for estimates of kW and kWh savings and payback (snapback) by hour for each event day conducted in 2009, at the participant level
6. Estimates of projected kW load impacts for different temperature conditions and control strategy

Sample Design

The objective of the M&V sample design was to produce a stratified sample that could support load impact estimation with a high degree of accuracy.

After reviewing the program data available, the sample was stratified by the three regions (Asheville, Raleigh, and Wilmington) in which the program was active in early 2009, and by number of air conditioners at the premise (one, or more than one). It was conducted in two waves - the second wave had the purpose to include Wilmington participants which had just started joining the program at the time of the first wave.

In this Report, “Asheville”, “Raleigh”, and “Wilmington” refer to regions defined by these cities and the surrounding areas.

The data collected for the first year of the M&V effort consisted of amperage meters deployed to a sample of program participants. These meters collected 5-minute data for 110 air conditioners in 77 participating residences.

Table A-1
EnergyWise 2009 Summer Program Participants and M&V Sample Size

Stratum*	Region	AC Units Per Participant	Air conditioner EnergyWise participants at time of sample design	% Participants	Number of Air Conditioners	% Air Conditioners	Target Sample Size (Number of air conditioners)	Actual Sample Size (number of air conditioners with usable data)
1 and 5	Asheville	One	80	6%	80	4%	5	5
2 and 6	Asheville	Multiple	29	2%	60	3%	5	4
3 and 7	Raleigh	One	696	53%	696	39%	36	32
4 and 8	Raleigh	Multiple	404	31%	840	47%	44	42
9	Wilmington	One	64	5%	64	4%	10	10
10	Wilmington	Multiple	31	2%	63	3%	10	10
Total			1,304	100%	1,803	100.00%	110	103

* Strata 1 to 4 constitute the first sampling wave; strata 5 to 10 are the second sampling wave.

System Load and Temperature Data Analysis for M&V Event Plan

In order to accurately estimate load impacts, it is important to collect data during EnergyWise control events and during days with no control events that have similar weather and schedule conditions. Further, the number of comparable days without events has to be greater than the number of days with events. This is because the days without events are the basis to estimate the baseline load, which in turn determines the load impacts. Because of this, a thorough analysis of weather data was conducted prior to conducting any events in the 2009 summer season. This analysis identified the number of baseline days that could be expected at each temperature range, and thus the number of M&V events that could be executed.

This section describes KEMA's analysis of NOAA weather data for July, August, and September of 1998 to 2008, for the cities of Raleigh, Wilmington, and Asheville.

Climate Zones

For the purposes of sample design and of this weather analysis, EnergyWise program participants were assigned to one of three areas: Raleigh, Wilmington, and Asheville.

When the sample was designed, using program data as of mid-June, 2009, there were 689 program participants, with a total of 935 installed devices[4]. Raleigh, Wilmington, and Asheville represented 81, 14, and 5 percent of the installed devices, respectively.

These percentages were used to create a weather data stream that is weighted by the geographical distribution of EnergyWise participants at the time the sample was drawn.

Temperature Analysis

KEMA utilized NOAA data for three weather stations[5] from 1998 to 2008 to determine the distributions of high temperatures in the months of July, August, and September. These distributions are presented in Table A-2.

[4] These figures exclude PEC employees participating in the Program.
[5] The NOAA weather stations utilized are:

3812	ASHEVILLE
13722	RALEIGH/DURHAM
13748	WILMINGTON

Table A-2
Distribution of Maximum Daily Temperature
July, August, September 1998-2008

Percentiles	ASHEVILLE			RALEIGH			WILMINGTON			WEIGHTED		
	July	August	Sept.	July	August	Sept.	July	August	Sept.	July	August	Sept.
100% Max	94	92	91	103	104	101	99	103	93	103	104	101
99%	92	92	89	100	102	94	98	98	93	100	102	94
95%	89	91	86	97	98	92	95	95	90	96	98	91
90%	88	89	84	95	96	89	94	93	88	95	96	89
75% Q3	86	87	81	93	92	86	91	90	85	93	92	85
50% Median	83	83	77	89	88	82	88	87	83	89	88	82
25% Q1	80	80	72	86	85	76	85	84	79	85	84	76
10%	77	78	69	80	82	72	83	82	75	80	81	72
5%	74	74	65	78	79	69	81	80	73	78	79	69
1%	68	70	61	71	69	66	79	77	69	71	70	66
0% Min	62	67	57	66	68	64	78	72	68	62	67	57

The distribution of high temperatures is very similar in July and August for Raleigh and Wilmington, the two locations with the highest weights.

The event strategy was designed with the following in mind:

1. The loggers for this project were installed between July 13 and July 18[6]. Thus, the first weekday of metering was July 20.

2. As mentioned earlier, in order to calculate an adequate baseline the number of hot days without an event has to be greater than the number of hot days with an event.

The expected number of hot days, and the proposed number of events, is presented in the following table.

Table A-3
Number of expected hot days and proposed number of events by temperature range

Maximum Daily Temperature (Weighted)	Expected Hot Days		Proposed Number of Events
	July - August	September	
98 or more	2	0	1
95 to 97	4	0	1
92 to 94	9	0	2
88 to 91	16	3	3
84 to 87	16	6	3

KEMA performed daily temperature tracking during the summer of 2009.

Analysis of PEC's system peaks

KEMA analyzed load data from January 1 to September 30, 2009, which included an hourly rank analysis (load duration curve) performed by PEC. PEC ranked the top system hours in this period, showing that as of September 30, the highest system load to date was registered on February 5, at hour ending (HE) 8 AM – a winter peak. The second highest hour is August 10, at HE 4 PM. The day with the third highest daily system peak was August 11, at HE 2 PM. As of

[6] This was done in order to balance remaining expected hot weather with more non-employee program installations, in order to obtain a more representative sample.

September 30, 2009, eleven of the top twenty highest system load hours in 2009 had occurred in winter.

KEMA's analysis shows that, subtracting the western region's load, the rest of the system peaked on August 11, at HE 4 PM.

PEC's ranking analysis shows that in 2007, the three days with the highest daily peaks were August 8 (HE 4 PM), August 9 (HE 4 PM), and August 10 (HE 3 PM). Two of the top twenty system load hours of the year were at HE 6 PM. All of the top twenty hours are between HE 2 PM and HE 6 PM. All of the top twenty hours are summer hours.

For 2008, PEC's ranking analysis shows that the three days with the highest daily system peaks were June 9 (HE 5 PM), June 10 (HE 4 PM), and August 6 (HE 5 PM). It also shows that five of the top twenty system hours were at hours ending 6 and 7 PM – fairly late in the day. Of these top twenty hours, two are at HE 2 PM, and only one is a winter hour (January 4 at HE 8 AM).

This analysis suggested that the window between hours ending 2 to 7 PM is appropriate to gauge EnergyWise's potential load impacts at time of system peak.

Cycling Strategy

PEC conducted a pilot program in 2007, during which PEC tested four levels of duty cycle reduction: 100, 65, 50, and 35 percent.

Based on PEC's 2007 pilot evaluation[7], and KEMA's experience with similar programs, PEC and KEMA agreed to:

- Cycle at 50 and 75 percent. The load impacts of less than 50 percent cycling are very small, making this an unlikely strategy in the event of a program activation triggered by system conditions.

- Not test a 100 percent emergency shutdown during the summer of 2009. These emergency shutdowns can be estimated by applying the estimated event non-response rate to the corresponding hourly load – thus reserving event hours to test strategies that are more difficult to model.

[7] Impact Analysis of Summer 2007 Residential Thermostat Pilot. Summit Blue Consulting LLC, 2008

Load Data Preparation

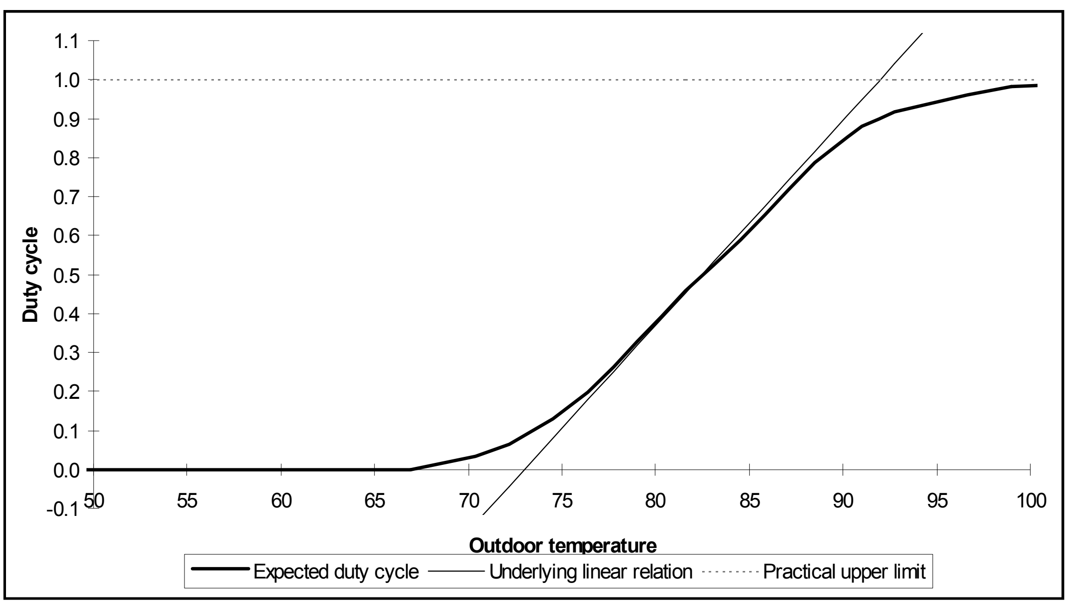
The load data for each sampled participant was individually analyzed prior to using it in the modeling effort. Data were screened for measurement errors or isolated readings that fall outside of the expected ranges.

Table A-1 reflects the number of installed loggers (Target Sample Size), and number of loggers that could be used in the load analysis and modeling (Actual Sample Size).

Model Specification

The Tobit duty cycle model used in this evaluation is fitted individually to each sampled program participant. The Tobit approach fits a simple linear functional form while taking into consideration that the percentage duty cycle data are censored at 0 and 1. Figure A-1 shows the underlying linear trend in relation to a smooth duty cycle curve. Estimating the linear model not in a Tobit framework will give results that do not account for the limits of connected load and can result in substantial overestimation.

Figure A-1
Duty Cycle Model Schematic



Two linear models are specified, with each corresponding to hot days, or mild days. If the maximum daily temperature is over 86°F, the day is considered a hot day.

The underlying hot day model specification is:

$$L_{dh} = I_h + \beta_{1h}\, AVGTHI_{dh} + \beta_{2h}\,(Evening{*}AVGTEMP1_{dh}) + \beta_{3h}\,((1-Evening){*}AVGTEMP2_{dh}) + \beta_{4h}\, AVGTEMP24_{dh} + \varepsilon_{dh}.$$

Where:

L_{dh}	= Duty cycle on day d hour h
I_h	= Hourly indicator variables
$AVGTHI_{dh}$	= Moving average hourly THI of hour h and previous 4 hours
$AVGTEMP1_{dh}$	= Moving average hourly temperature of hour h and previous 4 hours
$AVGTEMP2_{dh}$	= Moving average hourly temperature of hour h and previous 6^{th}, 7^{th}, 8^{th}, and 9^{th} hours
Evening	= Binary variable: 1 if hour h is between 8:00 PM to 12:00 AM
$AVGTEMP24_{dh}$	= Moving average hourly temperature of previous 24 hours
β_{1h}, β_{2h}, β_{3h}, β_{4h}	= Reference Cooling load coefficients determined by the regression
ε_{dh}	= Residual error

The cool day model specification is similar to warm day model, but with no evening variable:

$$L_{dh} = I_h + \beta_{1h}\, AVGTHI_{dh} + \beta_{2h}\, AVGTEMP_{dh} + \beta_{3h}\, AVGTEMP24_{dh} + \varepsilon_{dh}.$$

Where:

$AVGTHI_{dh}$	= Moving average hourly THI of hour h and previous 8 hours
$AVGTEMP_{dh}$	= Moving average hourly temperature of hour h and previous 8 hours
$AVGTEMP24_{dh}$	= Moving average hourly temperature of previous 24 hours
β_{1h}, β_{2h}, β_{3h}	= Reference Cooling load coefficients determined by the regression

L_{dh}, I_h, ε_{dh} remain the same.

The model specifications include different moving averages of the hourly temperatures and of the hourly temperature-humidity index (THI). For hot days, we find that AC load is driven primarily by temperature and humidity of the previous 4 hours during the day, and by the temperature and humidity of the current hour and the afternoon hours during the evening. The two model specifications allow us to adjust the models separately for hot and mild days, and daytime and nighttime during the summer months.

The THI variable utilizes PJM's THI equation[8]:

$$THI = (temp) - 0.55*(1\text{-}humidity/100) * (temp - 58)$$

The hourly THI variable is calculated using hourly temperature and hourly humidity. Because the hourly THI and temperature data is somewhat variable, and because cooling load clearly lags behind hourly THI and temperature, we use a moving average of the current and lagged THI and temperature data. The lagged THI and temperature data is the hourly THI from the first through fourth previous hours for hot days, the hourly temperature from the first through fourth previous hours for hot day daytime, the sixth through ninth previous hours for hot day evening, and the hourly THI and temperature from the first through eighth previous hours for the mild day model.

AC use differs with the time of day, driven by occupancy patterns independently of temperature. The hourly indicator variables are used to account for these differences in the regression.

The result of this model is the expected duty cycle of each unit in the sample. This estimated duty cycle is then multiplied by the connected load for each AC.

The connected load is the AC unit's electricity draw when the unit is running. This is equivalent to installed capacity – the unit will draw a kW amount within a narrow band when it's running, regardless of temperature or schedule. However, the temperature and the schedule – and in the case of program participants, the load curtailment event – will determine for how long it runs.

The final step in the modeling process is to estimate hourly average kW across all sampled AC units.

[8] PJM Manual 19: Load Forecasting and Analysis http://www.pjm.com/documents/~/media/documents/manuals/m19.ashx .

Appendix B: Verification of Metered kW

Prior to this study, the program's expectation was that air conditioner connected load would be higher than what is reflected in this study.

In order to verify the quality of the AC data utilized in the summer analysis, KEMA tested all of the loggers that were utilized in this study, and compared the rated tons to the connected load for the metered air conditioners. The results of this investigation are reported below

Logger Testing

KEMA's logger protocols include testing about 20% of all new incoming loggers.

Prior to deploying them, KEMA tested 22 of PEC-owned loggers in the following manner:

1. The loggers were launched at a one second logging interval
2. The loggers were attached to a known load (in this case, a fan and a lamp). All loggers are expected to record the same values at the same time.
3. During this test logging period, the load is varied by shutting off the fan.
4. At the end of the test, each file is downloaded and the following characteristics are checked to ensure the loggers are functioning properly:
    a) The correct current is recorded for the logging interval
    b) Current changes at the correct time and to the new correct value
    c) Launch and download are at the correct time.
    d) Correct CT size is listed in the file
    e) Correct Logger serial number is seen in the file
    f) Check for any other abnormalities in the file

If there are any problems with any one logger at any of the steps listed above, KEMA takes a larger percentage aside for testing to determine if it is a larger problem, or contained to a single unit. Since none of the 22 Hobo loggers owned by Progress Energy showed any problems, no further testing was performed before installation.

The EnergyWise team raised some concerns about the quality of the AC data utilized in the summer analysis, and/or the possibility that they were not properly installed. Specifically, that the CT used with the loggers might have been not adequate. In order to address these concerns, KEMA performed more in-depth testing of the loggers provided by Progress Energy.

The following steps were taken to test all 110 loggers:

1. All loggers were launched at a one second interval
2. All loggers were attached to a known load. In this case, a hair dryer.
3. At four recorded times, a spot measurement was taken of the current with an Amprobe hand-held tool.
4. The data collected by the loggers were downloaded.
5. Logger data was averaged to convert it from one-second data to one-minute data.
6. We then conducted the following checks using the logger data:
   a) The logger data for the minutes during spot testing were compared to the values recorded with the Amprobe spot measurements.
   b) Launch and download time are correct
   c) Correct CT size is used
   d) Correct logger serial number is seen in the file
   e) Check for any other abnormalities in the file

Prior to undertaking the load impact analysis, the data from six loggers had been excluded from analysis due to problems identified when the loggers were retrieved from the field.

The more comprehensive testing conducted on all loggers identified two additional problems: one was a logger that was excluded from the load impact analysis, and the other one is a logger that was programmed for a different size of the CT than used for this metering project. The loads recorded by this logger with the incorrect size could be scaled and utilized in the load impact analysis.

The final count of loggers used in the load impact analysis is reported in Table A-1.

Rated Tons vs. Metered kW

KEMA analyzed name plate data for units for which it was available, and compared rated tons, efficiency, and kW to the connected load obtained for each unit.

We do find that in the cases where the AC unit has a higher rated kW than what was metered in this project, this discrepancy is explained by the load associated with the evaporator fan. KEMA did not meter the evaporator fan of the sampled units, which is not under direct load control during EnergyWise events. These fans add an average of 0.4 kW per ton to the unit’s connected load, and are frequently included in the rated connected load of air conditioning units.

Appendix C: Examples of Non-Response

The following figures provide examples of the visual inspection used to determine whether units were responsive or not. These figures are based on five-minute load data between the hours of 8 AM and 9 PM.

Figure C-1 illustrates a case where the effect of the control is clearly visible. An AC unit that has been running continuously since 1 o'clock clearly cycles on and off during the event hours, and then resumes continuous operation after the event ends.

Figure C-1
Example of air conditioner load where the effect of the EnergyWise control is clearly visible

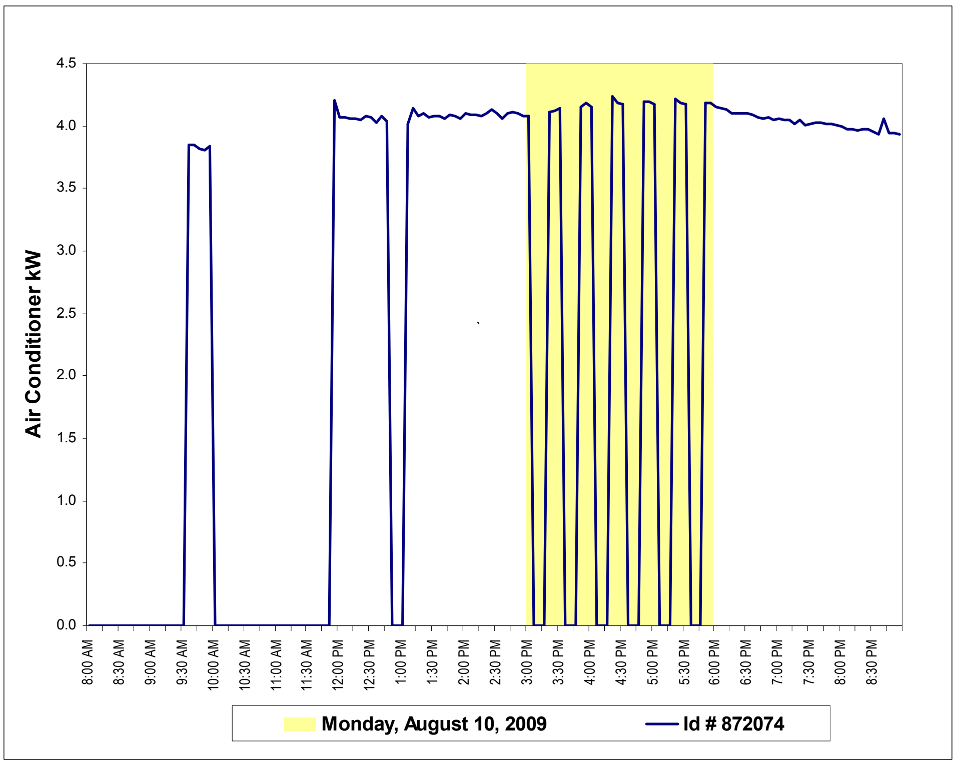
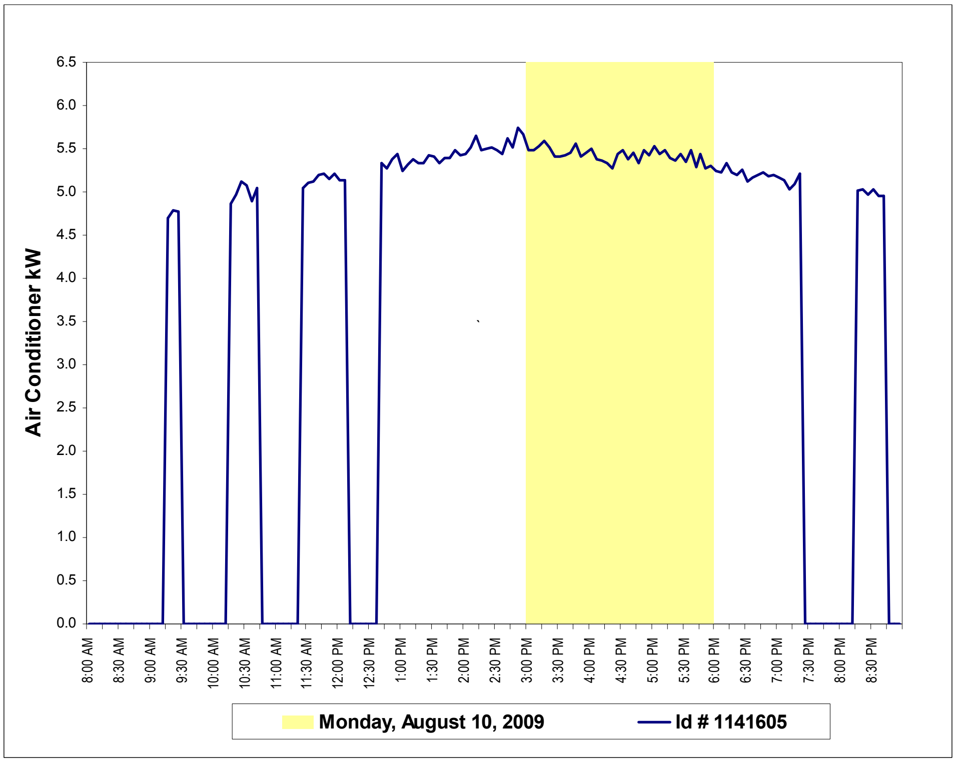


Figure C-2 corresponds to an air conditioner that clearly did not respond to the control. A unit that has been running non-stop since approximately 12:30 continues to do so until 7:30 PM. This particular unit failed to respond to most events conducted in 2009.

Figure C-2
Example of air conditioner load where the effect of the EnergyWise control is clearly absent



Last, Figure C-3 corresponds to a unit for which we were not able to determine whether it was responding to control or not. Comparisons of event hours to the hours before and after the event, and to other weekdays surrounding the event days, show that the unit's use pattern is not easy to discern, and thus it is not possible to determine whether the unit was controlled or not.

Figure C-3
Example of air conditioner load where the effect of the EnergyWise control cannot be visually determined